TWO SECTIONS—SECTION ONE

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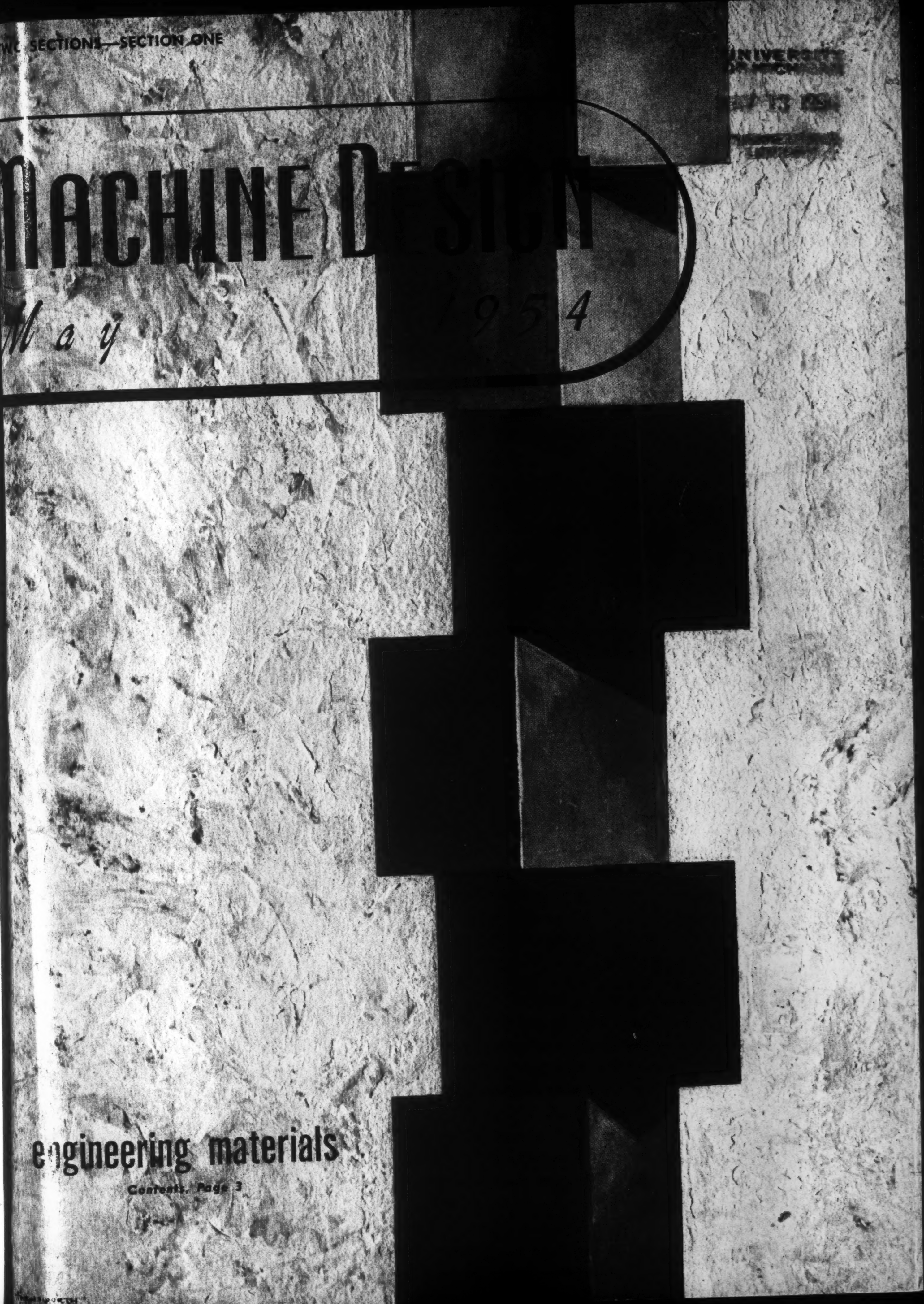
MACHINE DESIGN

May 1954



engineering materials

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ALLIS-CHALMERS

PUMPS for Designers

3 Ways to Save

1

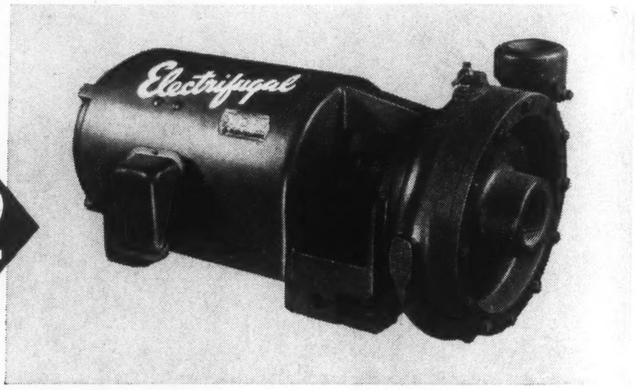
SAVE ENGINEERING TIME

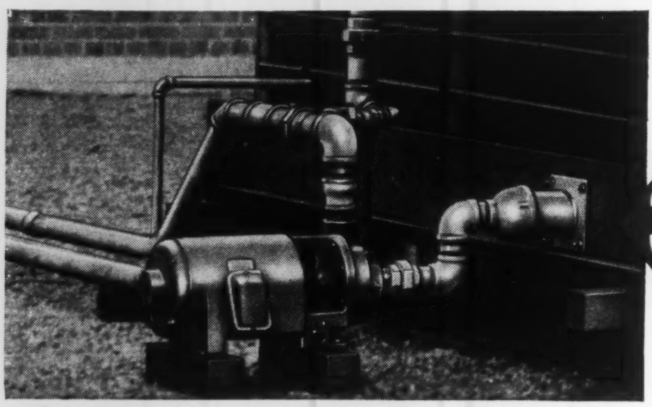
Allis-Chalmers representative will sit down with you in the planning stage and help you design the best possible pump set-up at the lowest cost. A-C field engineers will save you much costly engineering work and *guarantee* the complete pump and motor unit.

2

SAVE—NO EXTRA PARTS TO BUY

Designed as a complete, compact unit, Allis-Chalmers close-coupled pumps don't require extras — such as couplings, bases or shims. The pumps come as units ready to hook up and run!





3

SAVE ON INSTALLATION TIME

Bolt it down, hook up the line and piping, and your Allis-Chalmers pump is ready to go. There's no alignment problem. Correct installation is a big factor in pump performance and the A-C engineer will advise you at this point.

For more information about Allis-Chalmers designers' pumps, write for bulletins 52B6140, 52B7529, 52B6083 or 52B6975.

ALLIS-CHALMERS, Milwaukee 1, Wisconsin

FHP PACKAGE PUMP

Standard with mechanical seal. Widely used and accepted for air conditioning and refrigeration.

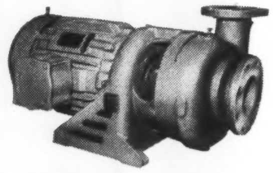
Bulletin 52B7529

Electrifugal

***ELECTRIFUGAL* PUMP**

A close-coupled pump with either conventional packing or mechanical seal.

Bulletin 52B6140



SUPPORTING ADAPTER PUMP

Flange motor and pump on sturdy supporting adapter. With conventional packing or mechanical seal.

Bulletin 52B6083

VERTICAL MOUNTED PUMP

Mechanical seal or sealless units with choice of submerged or sidewall mounting.

Bulletin 52B6975

Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

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THE PROFESSIONAL JOURNAL
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MACHINE DESIGN

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Over the Board

The Editorial We

Perhaps, like the daughter of one of our editors, you have wondered why editors always refer to themselves as we. Here's the answer she got: "So that the fellow who doesn't like what the editor has printed will think there are too many for him to beat up."

This Month's Covers

Previously our Directory of Materials supplement has been bound in with a regular issue (the last time was in October 1950), and has also been available separately at cost. With the directory separately bound this year, you will not have to tear apart the regular issue in order to have your permanent reference copy. At the same time you can get extra copies at a dollar per copy with discount on quantity orders.

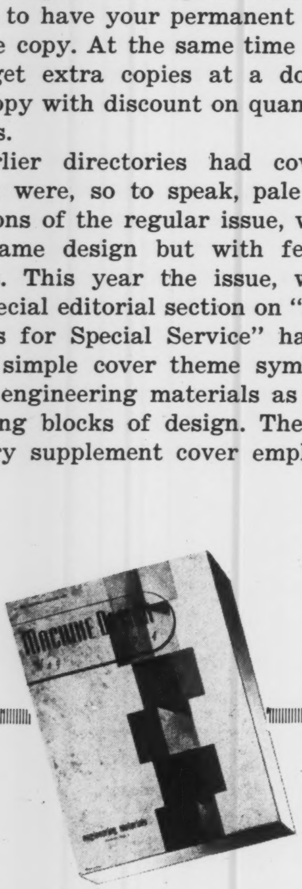
Earlier directories had covers which were, so to speak, pale reflections of the regular issue, with the same design but with fewer colors. This year the issue, with its special editorial section on "Materials for Special Service" has a bold, simple cover theme symbolizing engineering materials as the building blocks of design. The directory supplement cover employs letters alone to build a striking pattern which we know will clearly distinguish the volume from any other publication which may happen to be on your desk in the months and years you will be using your copy.

No Time To Write?

In our quest for top-notch articles we sometimes encounter potential authors who would like to write for us but are "too busy." We therefore were pleased to see going the rounds a breakdown of the number of hours in a year, which indicated that most people should have enough time to do what they really want. Check these figures with your own habits and see if you don't have time too, even allowing for that briefcase which you take home every night:

Hours in year, 365 days	8760
Sleeping hours, 8 daily	2920
Working hours, 40 weekly, 49 weeks	1960
Travel hours, 2 daily	490
Eating hours, 3 daily	1095
Dressing and undressing hours, 1 daily	365
Total hours consumed	6830
Do as you please hours	1930

The do-as-you-please hours are equivalent to 80 days of 24 hours each, nearly 22 per cent of the year, and almost identical with the working hours. Enough time to write several articles?



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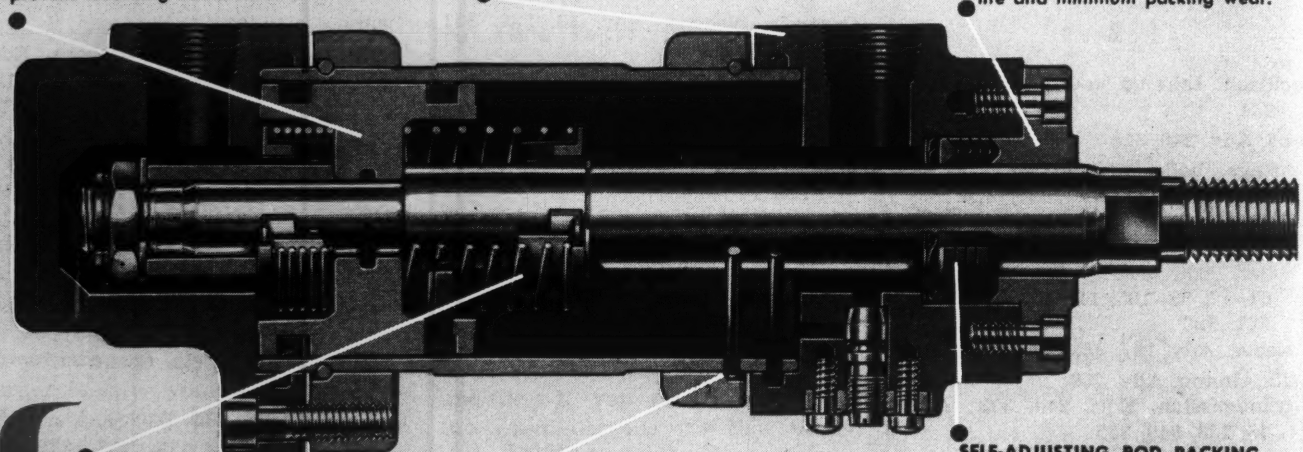
Announcing Hanna *Fluid* 750 SERIES *Power* Cylinders

Completely New in Design and Engineering

PISTON
One-piece steel construction, treated for corrosion resistance and grooved for block Vee synthetic packings which reduce friction and give more positive sealing. Piston rod nut is self-locking to prevent loosening under vibration.

HEADS
Sturdy construction of high-strength alloy iron permits operation at higher pressures with an increased safety margin. Interior and exterior of heads have special treatment to resist corrosion.

BRONZE GLAND
Provides high-strength rod bearing. Generous length contributes to long life and minimum packing wear.



HANNA CUSHIONS
New design assures positive cushioning over full cushion stroke — allows immediate full flow on return stroke. Simple to adjust for exact speed.

KEEPER RINGS
Construction provides easy head rotation and interchange of heads and mountings.

SELF-ADJUSTING ROD PACKING
J.I.C. Standard — 4 chevrons and bronze adaptors. Specially designed spring pre-loads packing — automatically compensates for wear.

We didn't design these cylinders with a "new look" in mind — although they have it. What's most important to you is their new performance . . . new operating features . . . and new versatility. The above cross-section illustrates some of the new features . . . study it. And there are other important features too: such as ground, polished, chrome-plated rods of alloy steel; cold drawn brass cylinder tubes; cushion adjustment dials; large fluid passages; and J.I.C. Standard leak-proof "O" ring gaskets.

In performance you will like the greater power developed from dimensionally smaller units in the Hanna "750" Fluid Power line. Because of their broad capacity range, air or hydraulic up to 750 p.s.i., you'll be sure of unusually smooth, dependable and lasting operation in the medium pressure ranges.

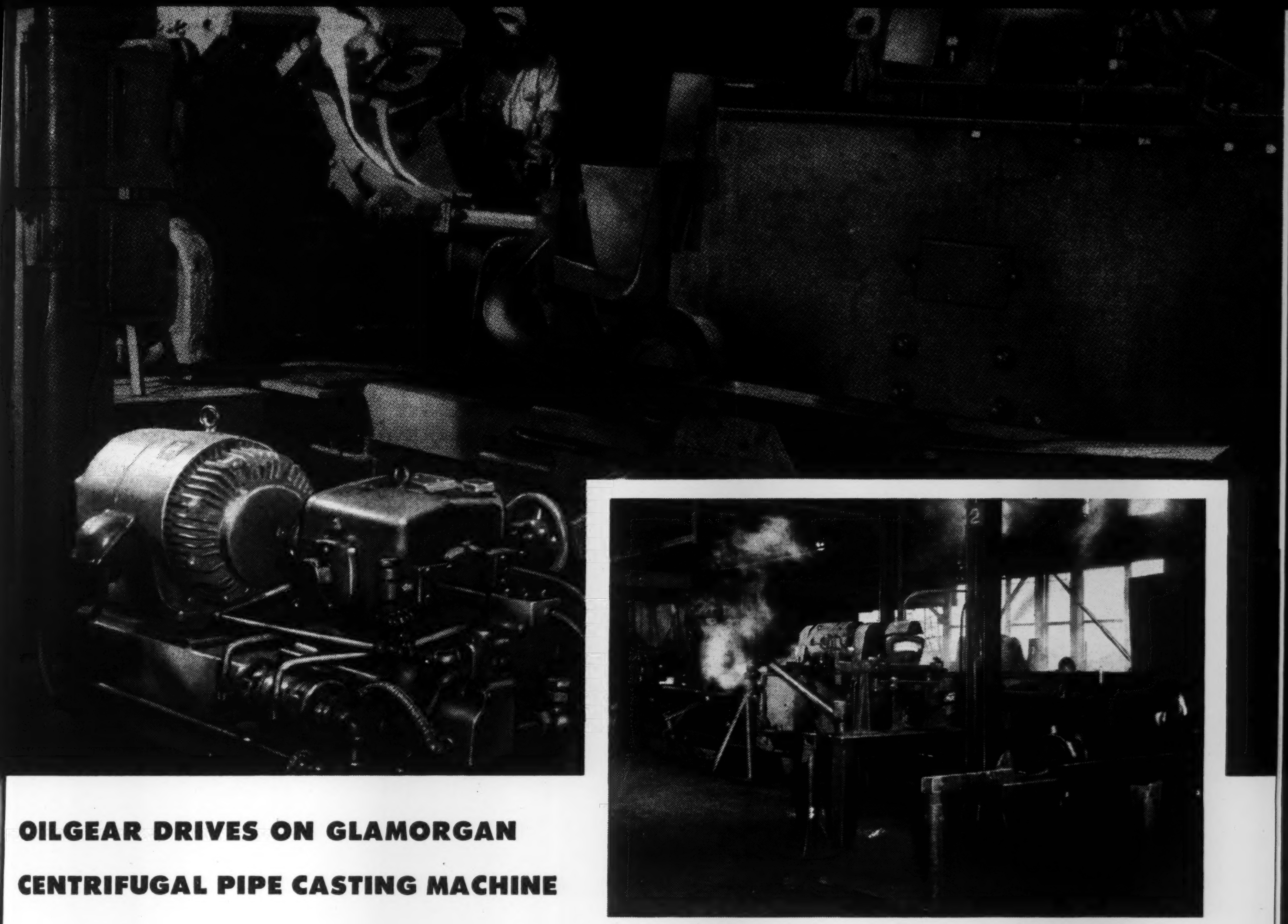
Yes, any way you look at them, inside or outside, Hanna "750" Fluid Power Cylinders are truly new. Together with their proved companions, Hanna LP and Hanna HP Cylinders, they offer a most complete range of capacities, sizes and mounting styles to exactly suit every cylinder application requirement.

Ask your Hanna Representative for details. We will gladly send you a copy of the new "750" Fluid Power Cylinder Catalog. No obligation—WRITE TODAY.

MOUNTING STYLES

Hanna Engineering Works

1751 ELSTON AVENUE • CHICAGO 22, ILLINOIS



OILGEAR DRIVES ON GLAMORGAN CENTRIFUGAL PIPE CASTING MACHINE

Something more than 5 years ago, the Glamorgan Pipe & Foundry Company, of Lynchburg, Va., a leading manufacturer of cast iron pipe, designed its own centrifugal pipe casting machine, using Oilgear Fluid Power equipment to tilt the ladle and move the casting carriage.

The degree of control over pouring rate and carriage travel afforded by Oilgear has had almost unbelievable results. Scrap caused by irregularities in moving parts has become negligible. Weight controls are well within the close limits set by Industry specifications. Only 3 men are needed to operate the equipment. Despite the fact the machine has averaged 500 operations per day since 1948, maintenance on Oilgear equipment has totaled less than $200.00. The fumes and dirt necessarily present in foundry operations have had no effect on Oilgear fluid power equipment.

TYPICAL OF OILGEAR'S ABILITY TO SOLVE MACHINE DESIGN PROBLEMS

Sure it takes power to tilt a ladle and move a pipe casting machine carriage. But above all, it takes absolute and precise control of the speed of pouring and the speed of carriage travel if the product is to be perfect and uniform.

It not only takes power but power under control to print in register on flimsy cellophane at high speed, to set up paper piles for repetitive serial cuts to hairline register automatically, to cut fish on a continuous conveyor to accurate weight for canning, to vary the speed of a large beater automatically to conform sensitively to the changing viscosity of the mass.

These are all triumphs of Oilgear Fluid Power—where this flexible, controllable, versatile power leads the way to better machine design or to the solution of hitherto unsolved problems.

Think of Oilgear Fluid Power as identical with electrical power . . . generated by a pump . . . applied over conductors through a motor or motor element. But Oilgear Fluid Power can be converted into linear movement as well as rotary; can be exerted statically, without motion; can be varied infinitely, steplessly without additional equipment.

And the unique Oilgear design is oil hydraulic design at its simplest and best. It is generally accepted as the leader in its field. It will cost you nothing to see what Oilgear can do to improve the salability of your equipment . . . may profit you and your users in an amazing degree. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.

OILGEAR

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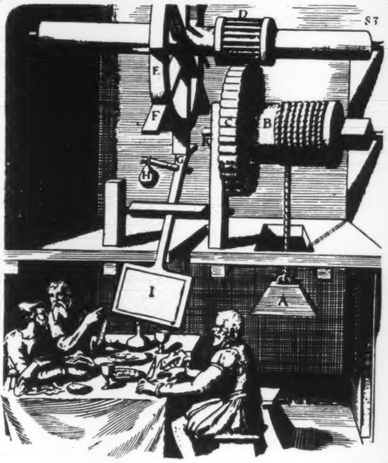


Courtesy The Bettmann Archive

Recognize it?

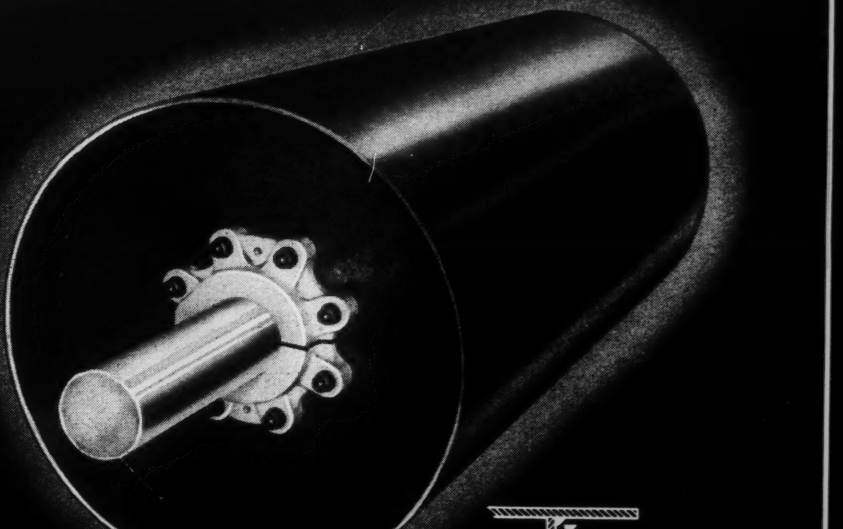
It's an "air conditioning" unit circa 1622. This cumbersome arrangement of wooden gears and weights, powered by gravity, operated the large paddle which fanned those seated below. Crude as it appears, it was an effective use of power transmission, and an excellent example of "imaginative engineering"—the kind which today produces time-saving, money-saving equipment like American Conveyor and Steel Split Pulleys.

Out of battered, beaten pulleys came a whole new concept of design

A graveyard of pulleys with gouged-out disc holes, fractured rim welds and enlarged hub bores was the start of an entirely new, "pit proved" line of American Conveyor Pulleys. Because they couldn't take high belt tensions over long distances, these battered pulleys put our engineers on a search for reasons why. By sifting stress and strength theories, cross-questioning empirical design and destruction-testing pulley parts, they found out what went on *inside* the pulleys. Result: a conveyor pulley capable of meeting any service demand.

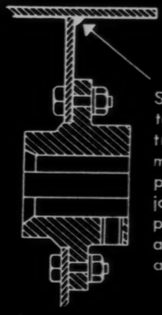
The American Steel Split pulley is another example of engineering imagination. This strong yet light-weight pulley—mounted or replaced without dismantling a shaft—revolutionized industry. With interchangeable bushings, steel split "packaged units" are available in over 500 sizes. Distributors nation-wide, stock these pulleys and bushings for quick delivery.

We think we have the answer to your pulley needs in our full line of pulleys. See your distributor today or write for information or engineering assistance. No obligation. The American Pulley Co. 4234 Wissahickon Ave., Philadelphia 29, Pa.

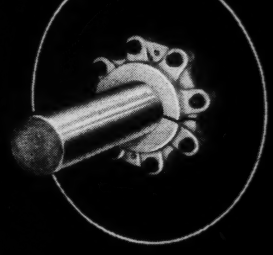


Rim thickness is carefully selected to suit pulley size and service. Crowning assures straight belt tracking . . . long life.

American Steel Split Pulleys run indefinitely under recommended belt loads. Can be operated at speeds up to 6000 feet per minute with an ample factor of safety. Oversize, easily accessible bolts hold pulley to shaft without keys or set screws.



Special welding techniques give extra strength and maximum weld penetration to all joints . . . assure proper alignment and fit of end discs and rims.



Wedg-Tite Tapered Hubs grab shafts in a 25% greater grip, make keys superfluous. Won't bell-mouth or walk on shafts. Easily installed or removed.

Hi-Torque Motor Pulleys with special laminated-veneer construction have high gripping power, overcome belt-slip, maintain their crowns and diameters longer than any other composition pulley.

"At the profit end of the machine"

Power Transmission by
AMERICAN
PULLEY COMPANY

MACHINE DESIGN Topics ...IN ENGINEERING AND RESEARCH

Bombarded Polyethylene Plastic Now Available

Having improved heat and chemical resistance over the conventional plastic, polyethylene irradiated by cathode-ray bombardment from a million-volt electron generator is now available in experimental quantities. Designated "Irrathene" by General Electric, the material in narrow-film form is expected to be used for electrical insulation and packaging. Chief improvements are form stability at 300-350 F, and resistance to cracking under stress and in contact with solvents or chemicals.

Hot-Air Heater Generates Own Electric Fan Power

Thermoelectric power is generated directly by a space heater recently developed at Rensselaer Polytechnic Institute to provide current for four small air-circulating fans. Patented built-in thermopiles, consisting of 2400 thermocouples, generate a total of 10 watts to operate the fans. Each thermocouple consists of two small metal pins, one of stainless steel extending into the combustion chamber and the other of copper extending into the cold outside air, connected by Chromel and Constantan wires. Pins are arranged in eight 4 by 7-inch panels, two of which supply enough current for one motor.

100,000-Volt X-Ray Weighs Less than 10 Pounds

A tiny particle of thulium (a rare-earth element) is the active part of an inexpensive, portable X-ray unit developed at Argonne National Laboratory. Made reactive in the heavy-water nuclear reactor at Argonne, the thulium particle is mounted in a unit which cost less than $40 for the first model, exclusive of irradiation charges. A ray is provided which is comparable in energy to a 100,000-volt X-ray machine, and the unit does not require an electrical power supply as used in conventional units.

Fast-Action Camera Automatically Develops Picture

Holding up to 200 feet of 35-mm film (2500 single frames), a new camera photographs, develops and projects a picture continuously and automatically within seconds. Depending on type of film used, time lag may be a little as 2 seconds. Single images can be held on the screen for an indefinite period. Designed by Kenyon Instrument Co. Inc. and called the Rapromatic 3000, the camera has been developed primarily for laboratory use in photographing oscilloscope traces.

Steel Developed for Magnetic Storage Drums

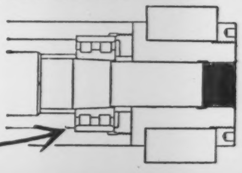
Designed specifically for magnetic storage drums of electronic computers, a high-alloy steel developed by Armco Steel Corp. is being produced in limited quantities. The 4 per cent molybdenum, 79 per cent nickel alloy is rolled under high pressure to very thin sheet for computer use.

Tungsten Machining Process Uses Ordinary Cutting Tools

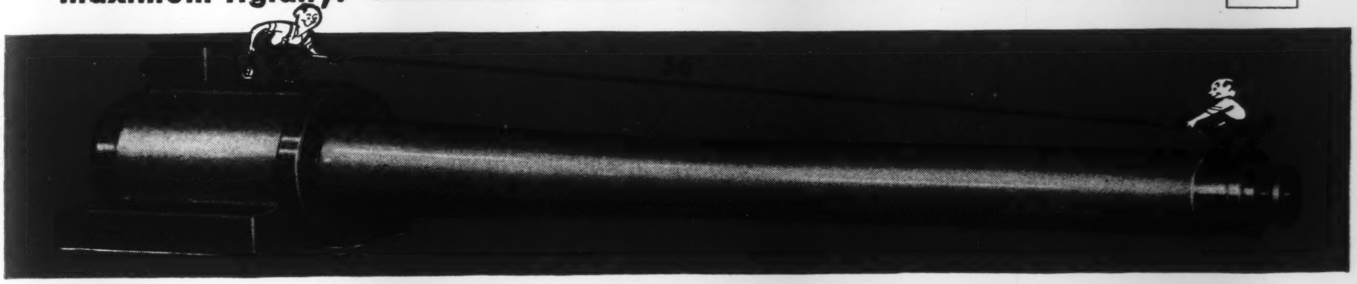
A new technique for machining tungsten with conventional cutting tools produces tolerances comparable to those possible with steel or brass. The Porphil process developed at Philips Laboratories Inc. uses a three-step

YOU CAN *Specify* POPE PRECISION SPINDLES WITH CONFIDENCE

TAKE THESE DEEP HOLE SPINDLES, FOR EXAMPLE

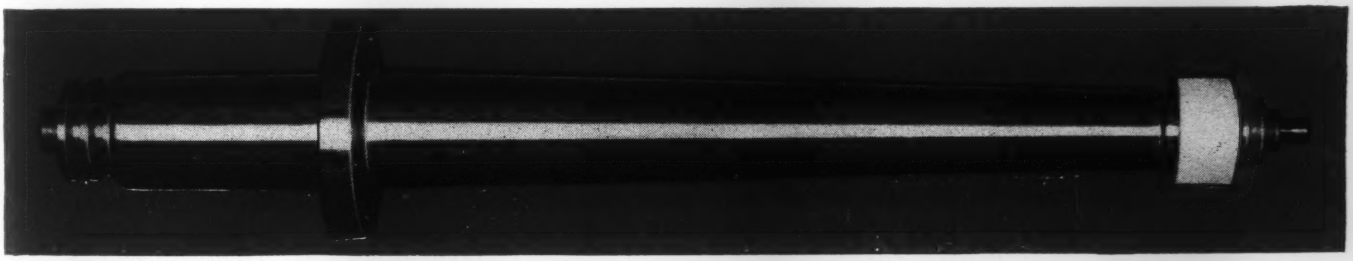


Only POPE Deep Hole Spindles are equipped with tapered bore, double row, cylindrical roller bearings close to the wheel for maximum rigidity.



POPE Deep Hole Spindles produce more holes per day because they can take heavy cuts; superior finished holes due to their shaft and bearing construction and Pope precision craftsmanship. Pope Spindles are dynamically balanced with all rotating parts in full assembly to insure smooth running and good grinding results.

Pope P-5886 Motorized Deep Hole Spindle — 75" over-all length, 4" barrel diameter at the wheel end, 6" at the motor end

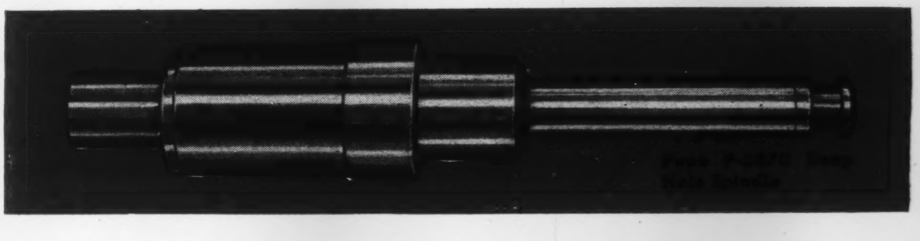


LUBRICATION — Pope System. The bearings are permanently lubricated for their entire operating life and require no further attention.

Pope P-16022 Belt Driven Deep Hole Spindle

If a fly lit on the inside surface of that deep hole, it's so smooth he'd fall down and break his leg.

— an actual comment made by the operator of a Pope Deep Hole Spindle to a shop inspector.



Pope P-[illegible] Deep Hole Spindle

Ask for detailed specifications and prices on Pope Heavy Duty Deep Hole Precision Spindles.

No. 98

Specify **POPE**

PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET • HAVERHILL, MASSACHUSETTS

method. Sintered tungsten ingots are first impregnated with a suitable wetting material with which tungsten does not alloy, such as gold or copper. Pieces are then machined, the impregnating material acting as a filler and lubricant. The wetting material is then removed by heating to below the sintering temperature so that distortion is not introduced, and physical characteristics are not affected. Densities up to 90 per cent of theoretical with easy machinability up to 83 per cent, can be attained.

Beryllium Copper Stands Up in Subzero Cold

Mechanical properties of commercial beryllium copper are able to withstand temperatures as low as −300 F, according to a recent study at University of Pennsylvania for The Beryllium Corp. Culminating a two-year investigation of wrought and cast alloys, the study of tensile and impact strengths, elongation and elastic modulus indicated that improved properties are sometimes displayed in the subzero range.

Back to Wooden Ships

Several hundred wooden-hull minesweepers are currently being built by the Navy in three different classes of vessels. The largest, the AM-421 class, are 165 feet long and displace 750 tons. The AMS-60 class is the middleweight; ships are 144 feet long and displace 375 tons. Baby of the group is the MSB, a lusty infant only 57 feet long which is transported by and operates from a "mother" ship.

Shaft Deflection Detector Shuts Down Vibrating Turbines

Persistent vibration of turbine shafts, indicating load unbalance and shaft deflection, is detected immediately by a warning and shutdown device developed by Allis-Chalmers for hydroelectric stations. Two induction coils adjacent to the shaft pick up and measure extent of unbalance. Momentary vibration during load changes is disregarded, but a warning is flashed when vibration persists, and the turbine is shut down when the danger point is reached. The device thus has no moving parts.

Noncritical High-Temperature Alloy Developed

A new high-temperature alloy of noncritical materials shows promise as a substitute for stainless steels in many applications. Named Thermenol by the Naval Ordnance Laboratory, the metal is 20 to 25 per cent lighter than stainless steel, and has a high tensile strength coupled with high resistance to corrosion or oxidation. Preliminary creep-to-rupture tests indicate that at 1200 F Thermenol is "better than some forms of stainless steel being used widely in the aircraft industry today." Possible applications are said to be jet tailcones and exhaust systems, heater elements in toasters, low-temperature furnaces, and electric appliances.

Mothball Fleet Gets Sacrificial Protection

Reserve fleet ships harbored at Wilmington, N. C., are protected from hull corrosion by sacrificial electrodes buried in the mud near the ships. In a system developed by G-E and the Maritime Administration, the submerged electrodes are connected to on-shore rectifiers and then to the hull. The rectifiers set up a dc voltage between the submerged portion of the ship and the water, causing the electrodes to corrode rather than the ships.

MACHINE DESIGN

MAY 1954

Designing for Low Cost and Hard Sell

AS SUPPLY catches up with or exceeds demand in virtually all types of goods, the "hard-sell" or "buyer's market" type of economy is again upon us after a long absence. For all but the timid and lazy the situation presents an opportunity and a challenge rather than a cause for misgivings.

For design engineers it seems to have been the signal for renewed attacks on the problem of reducing costs. MACHINE DESIGN's most recent study of design engineers' problems shows not only that more attention is being devoted to cost reduction than to any other aspect of design activity, as always, but that its importance has increased to an all-time high.

As in the previous study, production methods and improved appearance rank next in order of importance. The tie-in of production methods with cost reduction is obvious, while the emphasis on improved appearance reflects an awareness of the "hard-sell" market where attractive appearance may turn the trick in a close sale.

But the most significant fact brought out by this latest study is the increased emphasis on materials selection, which in one year moved up from eighth place to fourth place with an increase of 22 per cent in interest. It is another important facet in cost reduction. Particularly timely, therefore, is the double-barreled attack on the materials selection problem in this issue. A special section in the regular issue plus the companion directory of tradenamed materials provide specific data on selection, application and specification of engineering materials.

The many hundreds of materials discussed and listed in these two features offer abundant opportunities for redesign at lower cost as the result of improved service and processing characteristics. Many of these materials also possess natural qualities of appearance which can be valuable in designing for sales appeal. Thus can design engineers mobilize engineering materials as powerful weapons in meeting the tough competition that lies ahead.

Colin Carmichael

EDITOR

" . . . when management spends time examining products critically with a view to developing strong lines, many of their other problems disappear . . . "

Photo, courtesy D. W. Onan & Sons Inc.

Developing Strong Product Lines

By Philip R. Marvin
Vice President
Commonwealth Engineering Co.
Dayton, Ohio

A GROWING buyer's market is demanding sound products. Profits are proof of product performance and where performance is lacking, profits are usually absent too. Buyer's markets always place emphasis on the need for strong product lines.

Most businesses operate to sell a product. This product must meet the test of performance; it must do the best job, in the best way, at the lowest cost possible. As time passes products must be redesigned to incorporate new materials and methods and to do new jobs. Constant scrutiny is necessary to see where performance can be improved, to see where new functions can be added, and to see how costs can be reduced. Competition forces this responsibility on every manufacturer who wants to stay in business and grow. Buyer's markets emphasize the need for strong product lines. Industrial and consumer items must be strengthened to maintain and dominate markets. Profits fall if this isn't done.

These fundamentals underlie profitable products:

1. Profits, stability, and growth depend upon strong product lines.
2. Sound engineering is the basis of sound products.
3. Modern management methods are vital to engineering effectiveness.

Developing Product Perspective: Neglected products are often the dominant factor contributing directly to business failure. Strong product lines can carry a business through critical periods safely. Weak product lines increase selling costs, and poorly designed products ask the impossible. They place added burdens on selling and advertising functions. They increase operating expenses, create inventory difficulties and require unnecessarily large investments.

When management spends time examining products critically with a view to developing strong lines, many of their other problems disappear. Engineers recognize this important fact.

Recently, the president of a firm manufacturing a high-grade line of counter-top scales admitted that after having maintained a good sales position for over 75 years of the firm's history, they now faced an unfavorable outlook. For over 100 years his firm has maintained a sales volume that hasn't fluctuated more than 5 per cent.

For 75 years every time volume started to dip, the salespeople were told to do something about it, and they did do something about it—they chased frontier markets across the United States, South America, and Africa. Right behind them came manufacturers with scales of more modern design.

The president wanted to know what they could do to revamp their sales approach. This case accentuates a rather common failing of too much emphasis on either selling, finance or production func-

How engineering management can plan and operate for profits, stability and growth

" . . . no single phase is more important in the company's activities than product design . . . "

Photo, courtesy Allis-Chalmers Mfg. Co.

tions and too little on the product aspect. No single phase is more important in the company's activities than product design. Products are the reason for being in business.

The Engineer's Function: Engineers have the job of making products at the lowest cost consistent with performance requirements. Competent engineers know how to recognize problems and how to apply accumulated experience and knowledge in selecting the best solutions out of the available alternative courses, not on the basis of the right versus the wrong, but solutions exemplifying the most feasible approach in the light of practical considerations in the situations that exist.

To qualify as an engineer a man must undergo rigorous training in the physical sciences, develop experimental skill and acquire a thorough knowledge of current technology. This background followed by practice over a period of years working under senior engineers develops engineering competency which is characterized by two requirements.

First, the engineering job requires skill in analytical methods — skill that must be developed through study and practice. Management men who use an analytical approach substitute fact and law for force and opinion. This is powerful medicine for business problems.

Engineers don't have any exclusive claim to analytical methods; scientists, physicians, and lawyers and others are schooled in analytical techniques, but this general analytical approach is important to businessmen and is available to them through their engineers.

Altogether too many of our "experts" have missed the important concept of this analytical approach and lack the training and skill to apply it. As a result, a lot of "hokum and magic" appear under the guise of scientific management. Businessmen want to buy something they can see and engineers have a good record of delivering visible and tangible results.

Second, this job requires a grasp of product concepts, and this is a second reason why engineers make a valuable contribution to management. Most firms are in business to sell a product, which may be a hardware item such as an automobile or a service item like telephone communication. Engineers are familiar with product concepts while nontechnically trained executives sometimes forget about products and often fall into the error of regarding the product as a necessary evil but otherwise unimportant to the operation.

Management's Job: Product design calls upon many highly developed and specialized skills. Coordinating these skills is a job and skill in itself. Just as time and money must be spent in acquiring and developing other specialized skills, so must time and money be spent in proportional amounts

Administrative Approach to Problems

RECOGNITION OF PROBLEMS

is not as easy as sometimes appears upon superficial observation. The fact that operations are in a dynamic rather than static state introduces a constant shift of scene that frequently confuses understanding of the actual workings of the operations themselves. Problems may be the result of operational factors situated remote to the point at which the difficulty is encountered.

Difficulty in problem detection creates opportunity for the skillful strategist who wishes to conceal his weaknesses by shifting responsibility or introducing delaying actions and applying other strategies. Before a problem is traced to the source a new problem may appear starting a search in a different direction. It should be obvious that unless a problem is recognized in its actual position in the operation there is little chance of taking effective remedial action.

OBSERVATION OF THE PROBLEM AREA

for a period of time before taking any action is a sound procedure in the administrative process. Such observation affords the opportunity of again checking to make certain that the problem area has been traced to its focal point. In addition it allows the executive to become thoroughly familiar with the workings of this particular problem area.

In mature organizations, established and set in their ways, problems have a tendency to recur at periodic intervals. Close observation by the executive of the workings of the problem area prior to any action gives him two advantages. He becomes so familiar with the nature of the problem area that he is able to recognize it at an earlier stage when it recurs at a later date, as it probably will. Moreover, the executive has the opportunity to gather such a thorough working knowladge of the situation that he can strongly refute, when necessary, any arguments advanced against his final proposal.

DEVELOPMENT OF TENTATIVE APPROACHES

to solution of the problem should follow the observation period. Recognition of problem areas and attentive observation to actual interworkings places the executive in the very best position to develop tentative approaches to the problem.

Time should be taken to get all of the proposed solutions down on paper. While the particular problem area's relationships are clearly in mind, the solutions that suggest themselves should be noted. Too often, sound approaches to solutions have been overlooked because they were not recorded.

REVIEW AND ANALYSIS

of the proposed solutions are facilitated greatly by having them on paper. Some solutions can be regrouped because of the similarity of steps. Preliminary analysis will reject others because of obvious elements of impracticality. Certain proposals will appear to be sounder than others. These should be placed at the head of the list. Review, analysis, and shuffling of the initial group of proposals shake the proposals down and out into a refined group. It should be carried out largely without recourse to any particular amount of detailed study. This work sets the background for further analysis.

COLLECTION OF SUPPORTING DATA

can be carried out with maximum objectivity when it is separated from any process of evaluation. The job now is to get data. Study each tentative approach. Determine the data necessary to evaluate this approach. Collect these supporting data.

Emphasis is placed at this step on digging for every scrap of pertinent data. Don't weigh facts at this point. Weigh the degree of accuracy and get the facts down in the record. This stage is completed when all essential information has been gathered supporting each tentative aproach.

SYNTHESIS OF THE COURSE OF ACTION

to be taken starts with final evaluation of the proposals. Study of the data gathered makes possible not only the weighing of one proposed course of action against another, but permits the selection of the very best elements of each. These then can be combined into the action that is taken. This is a key point in the administrative process. Here is assembled the working data for important executive action—the formulation of a course of action directed at the solution of a problem. The problem may be one concerned with organizational development or stability. While the executive is concerned with planning, organizing, or controlling, above all, he is the man who decides how problems are to be attacked. Having isolated the problem, he develops tentative approaches to the problem area, assembles data, formulates a program, and puts it into action.

TESTING OF PROGRAMS

establishes their soundness. When two equally attractive courses of action present themselves, both should be tested where feasible. Executives need to know the answers to the questions. "How can I be sure?" and "How sure can I be?" They get these answers by testing final program selections.

Two administrative alternatives exist from the outset in any problem area, one of action and one of no action. If action is apt to make a situation worse, this probability may dictate a "leave well enough alone" attitude. On the other hand, if executive action is to be taken, the executive should attempt to pretest his plan. Testing offers the opportunity of gaining experience at small risk. Administratively, testing is too little used. The scientist goes from an idea to the research library, then to a table test, then a pilot plant, and then a unit operation before he breaks ground for the multiunit plant. Executives too often jump and fall short.

APPLYING TEST RESULTS

usually requires some final compromise. Compromise shouldn't be considered a step backward. This is one of the advantages of the test. If a plan is known to be perfect it doesn't require testing. The purpose of the test is to learn exactly where the plan falls away in performance from the direction of the desired results.

The test tells the executive of points in the proposed plan that must be given further consideration. Even so, it may be necessary to put the plan into action without further delay. Time may not permit further revamping the program. In this event the executive can still act in an informed manner.

Compromise with all factors at this point is sound administrative practice. Perfection in administration is desirable but performance is essential. One of the hardest indoctrination jobs in developing the executive is that of instilling a concept of performance percentages. Simply stated it is this: It takes a lot of 100 per cent perfect performance to offset delays to achieve it.

For example, performance at an 80 per cent level over a period of 10 months represents 2 lost months. But if a 6 month's delay in operations is necessary to achieve a 100 per cent effective operating program, it will take 3 years before the gain in effectiveness will be realized. This is a very practical concept. Operating executives must always measure effectiveness-in-performance; this is their product.

Re-examination of the proposed course of action along with the operating experience from the trial period forms the basis for final adjustment.

PUTTING THE PLAN INTO OPERATION

would appear to be a step in the administrative process that shouldn't require any emphasis. Experience is witness to the fact that here is frequently a point of failure.

This is a rather special phenomenon in executive action. There are parallel cases. In early life some individuals exhibit test-reaction tendencies. These people can't seem to answer examination questions even though they appear to have a good understanding of the subject matter. We hear of speakers and singers who appear to be struck "dumb" when they appear before a microphone or an audience. Many executives exhibit a tendency to develop "buck fever" when the time approaches to actually put a plan into operation—action they are convinced is sound—and they always appear to have "good" reasons.

" . . . programming is the critical transition of the executive's thinking into a definite plan of action . . . "

Photo, courtesy Armstrong Cork Co.

to acquire and develop administrative skill. This concept is not yet fully understood by all those who profess to recognize the role of professional management. Management has a major responsibility of tying the work of the product experts together into one working team. Co-ordination is a process of providing an invigorating working atmosphere with smoothly functioning communications to maintain balanced operations. When this is working smoothly, the co-ordination process is neither seen nor heard.

Management needs quick solutions and fast-moving programs. Sound products result from objective approaches. Good results have come from the following six-step programming plan that is based upon successful product development experience in a number of corporations.

Survey and Summarize Requirements. This is the first step. Look around, see what's going on; don't do anything else but look. Executives who fail to make a careful survey at the outset generally fail because of lack of confidence in themselves. It takes a man of skilled administrative ability to admit that he faces a new situation and to admit that he better get acquainted. Usually those who rush into action feel that they must show who is boss because they aren't too sure themselves who is. The survey has a purpose. The purpose is to develop requirements.

Determine Strengths and Weaknesses. A catalog of strong and weak factors is an invaluable tool. It establishes reference points. Administrative action always has direct and indirect effects and an early cataloging of strengths and weaknesses serves as a valuable reference in developing programs, analyzing their probable impact, and in reviewing performance.

Due to the continual change in any operation it is important that this catalog be kept up to date. At all times it should represent an accurate picture of plus and minus factors in the operation.

State Problem Areas in Order of Importance. The catalog of strong and weak operating factors is the basis for selecting problem areas of major importance. Maximum effectiveness is achieved by tackling problems in order of importance. A common weakness lies in tackling problems as they arise. Following this practice may lead to over-expenditure of time on relatively minor problems.

Analyze the Selected Problem Area. Having chosen a problem area for study on the basis of its relative importance to operations, the executive is assured that he is applying his time to the proper problem.

The analysis itself should be approached in the same manner in which the overall operation was studied. First, a survey of the selected problem area; second, a determination of its strengths and weaknesses and third, a statement of the problem elements in order of importance. Sound administration involves a lot of screening and sifting. There is no shortcut.

Develop a Plan. Programming an attack on problems calls into play all of the executive's engineering knowledge, judgment, and experience. His knowledge of fundamental principles involved in the problem provides a framework for reference. His judgment as to phases upon which he must capitalize, phases to which he must cater, and phases which he must modify is important in manipulating factors in the problem. Finally, his experience has trained him to work with a minimum of false starts and lost motion.

" . . . competent engineers know how to recognize problems and how to apply accumulated experience and knowledge in selecting the best solutions . . . "

Photo, courtesy Designers for Industry Inc.

Programming is the critical transition of the executive's thinking into a definite plan of action. Generally the fault, when it occurs, is not with the programming itself but its phasing. Programming too soon, before careful analysis, is based upon immature concepts of the real problem and its relative importance.

As problems come to the attention of executives, there is a natural tendency to jump directly to planning a solution. Recognition of the importance of the less obvious intermediate phases sets successful administrators a cut above their fellows. The principles discussed in detail in the accompanying outline offer a sound and practical administrative approach to problems with a minimum of pitfalls.

SELL THE PLAN INTO OPERATION. The critical step in any engineering program is getting it into action. Management develops plans, others do the work. Because of this executives must sell the plan into operation. The voice of authority alone is never sufficient to do this job effectively. On the other hand, a carefully developed selling attack can be quite successful.

The development of a sound plan is the first important step in getting a program into action. A sound program that unfolds in a logical pattern to accomplish some specific objectives represents a salable commodity.

Establishing acceptance of programs by those who are to put these programs into action is the second step. If the program itself is sound it may be acceptable on its face value. However, one should never assume this. Get the individual who is going to undertake the program to state his conviction in the program. This commits him.

The next step is to convince others that the program is vital to success. In other words, the program is not only sound but must be put into operation in order to accomplish any results.

The executive must demonstrate the program,

" . . . product design calls upon many highly developed and specialized skills . . . co-ordinating these skills is a job and skill in itself . . . "

Photo, courtesy Allis-Chalmers Mfg. Co.

dramatize its value, and convince others that beyond the shadow of any doubt this program must go forward.

A plan properly sold is always much more successful than a plan that operates on the basis of halfhearted acceptance. Since executives must depend on others to execute programs, selling deserves considerable attention.

Recruiting Engineering Administrators: Management teams need willing and able technical talent. Two aspects of the engineer's training and experience that management men are capitalizing on today are his ability to make an analytical approach to problems and his grasp of product concepts.

It is hard for some management men to believe that everyone is not eager for a management job. It is equally unbelievable to some very capable engineers that anyone wants a management assignment. These two points of view must be recognized. The fundamental point to keep in mind is that men who are selected for management jobs must have ambitions in this direction. Willingness to accept a management post must be explored in considering an engineer for a management assignment.

To qualify satisfactorily for an administrative assignment, the engineer must also have managerial capacity. This doesn't necessarily call for top-flight specialized engineering talent. Technical proficiency is no more of a basis on which to judge managerial ability than management proficiency is a basis for judging a man's capacity as an engineer. But the man chosen must have a knowledge of management fundamentals and the capacity to handle the human relations involved.

Transfer of Skills: Developing engineering management for sound product lines is a difficult task but it isn't easy for competitors either. Engineering calls for emphasis of individual skill. Management calls for emphasis on the development of people and co-ordination of their output. After a man has been rated on the basis of his own individual output for a number of years, it is hard for him to adjust himself to the job of devoting his time to co-ordinating others.

Those who make this transition successfully are engineers who recognize that they can multiply their individual effectiveness manyfold in management positions. By building a strong organization more work can be accomplished than if it were undertaken by them individually.

Planning for the Future: Advancing technology is continually placing added burdens on businessmen. In the days to come this burden will increase even more. It bears repeating to say that business can't stand still—it either grows or decays. To maintain industry position you must grow along with competition.

Pioneering and progress are coupled to the ability to understand and to utilize new technical developments. The research laboratory opens the door to scientific frontiers but industrial management must take the initiative in programming product development.

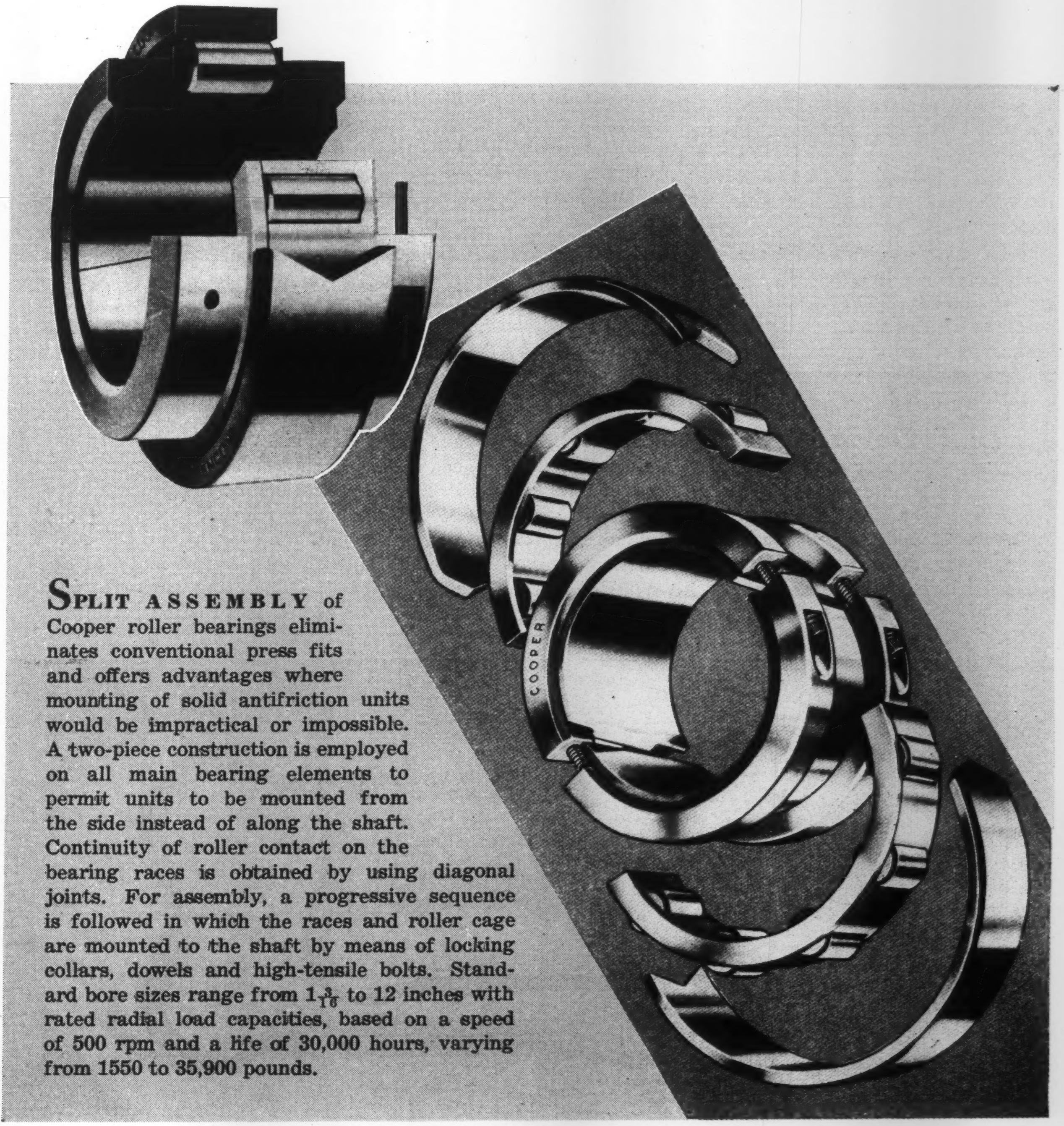
Looking ahead, what effect will atomic energy have on business? What new opportunities does the commercial development of titanium offer? What does automation offer? How should computers be put to work?

Appraisal of the significance of all such developments calls for engineering talent on the management team—talent that takes an analytical approach to management problems and talent that recognizes the technical significance of product problems in a going business. Developing engineering management for strong product lines in the all-important final analysis spells profits, stability and growth.

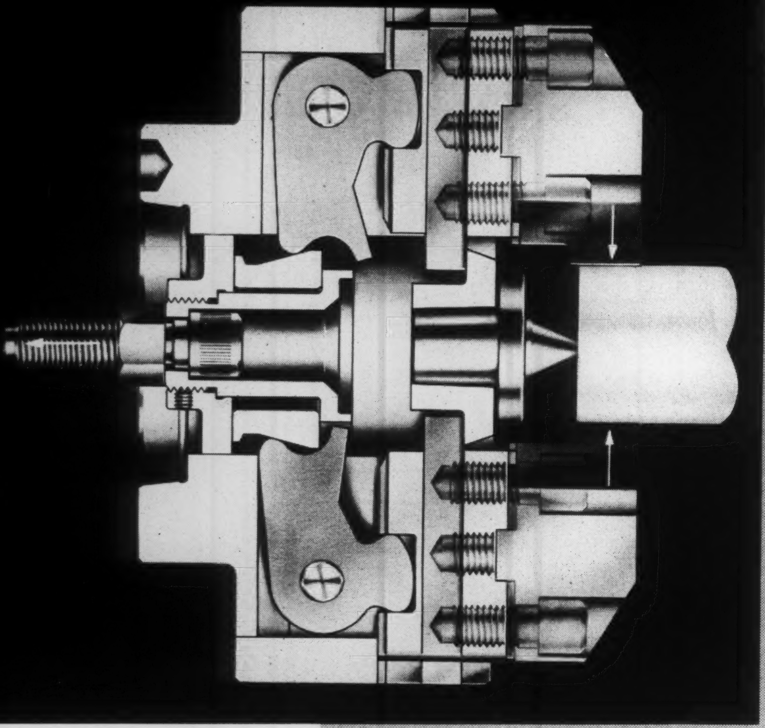
". . . the executive must demonstrate the program, dramatize its value, and convince others..."

Photo, courtesy Armstrong Cork Co.

SCANNING the field for IDEAS



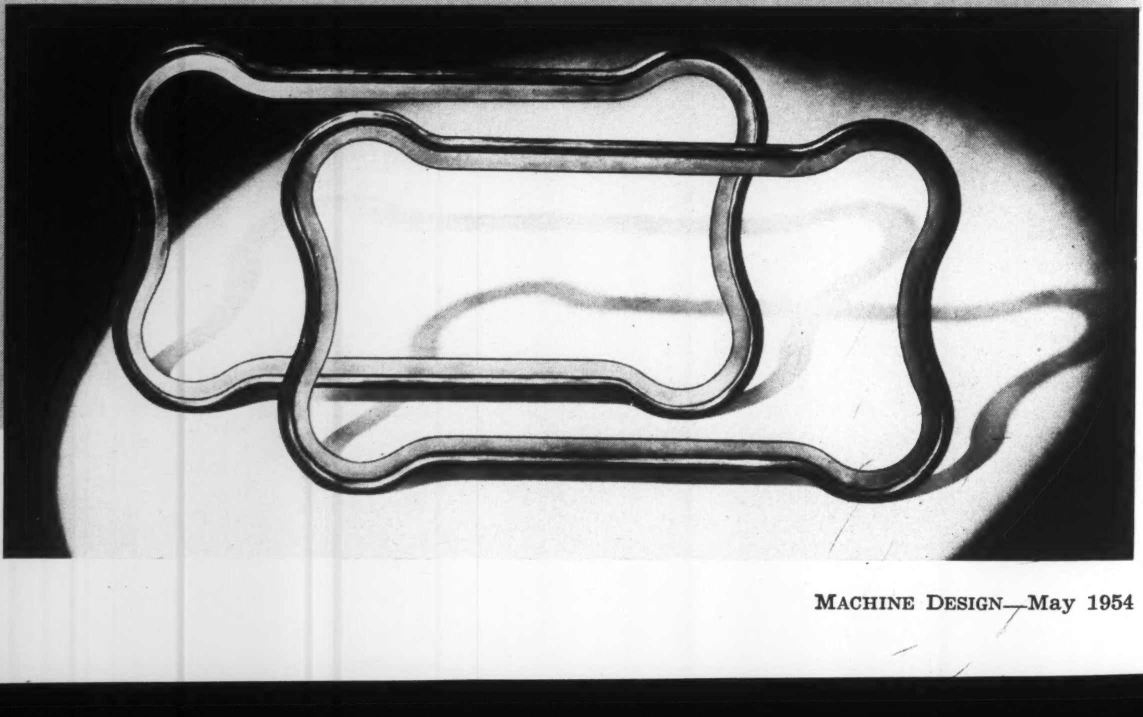
SPLIT ASSEMBLY of Cooper roller bearings eliminates conventional press fits and offers advantages where mounting of solid antifriction units would be impractical or impossible. A two-piece construction is employed on all main bearing elements to permit units to be mounted from the side instead of along the shaft. Continuity of roller contact on the bearing races is obtained by using diagonal joints. For assembly, a progressive sequence is followed in which the races and roller cage are mounted to the shaft by means of locking collars, dowels and high-tensile bolts. Standard bore sizes range from $1\frac{3}{16}$ to 12 inches with rated radial load capacities, based on a speed of 500 rpm and a life of 30,000 hours, varying from 1550 to 35,900 pounds.



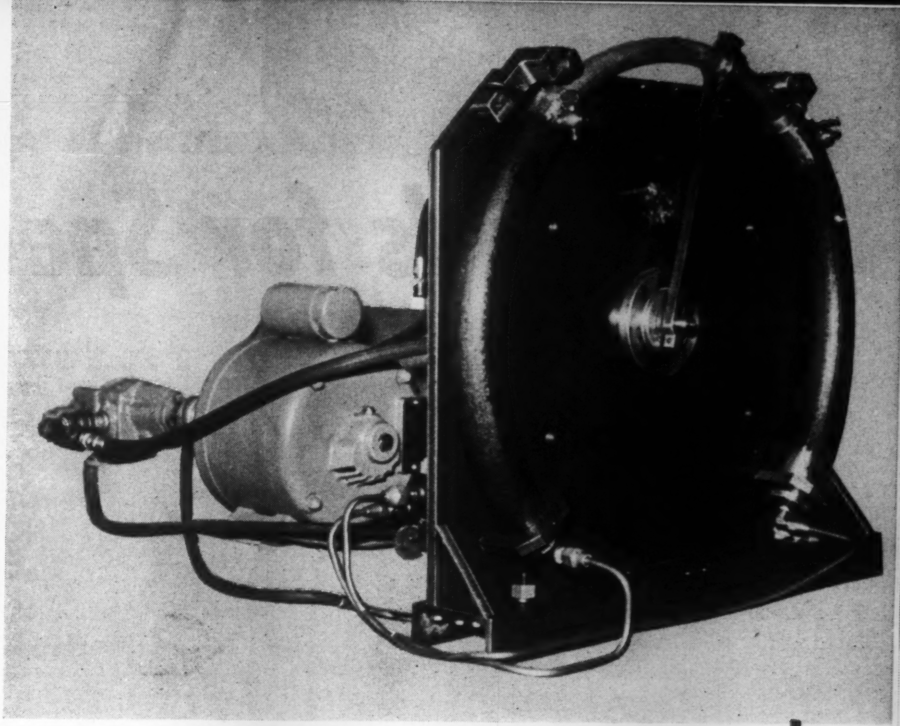
AUTOMATIC EQUALIZING of jaw pressures in a compensating chuck design developed by S-P Mfg. Corp. is accomplished with a lever system employing a "floating" cam. Multiple jaw movements are controlled simultaneously by the system to assure secure, uniform locking of center-mounted parts with irregular or out-of-round surfaces.

In operation, the jaws are driven by separate levers which engage the tapered surfaces of a cylindrical cam free to move radially. As power is applied to the cam through an axial screw attachment and in the longitudinal direction, engagement of each jaw with the uneven part surface stops the motion of its mating lever and causes the cam to shift radially until forces at all jaws are equalized. High gripping pressures are achieved with the design which resists centrifugal forces and heavy torsional cutting loads.

BONDED GASKET ASSEMBLIES of rubber and metal offer a rigid construction and facilitate mounting of irregular shapes. In a process developed by Acushnet Process Co. for use on aircraft engines, conventional flexible rubber gaskets are reinforced with a metal rim to form a stiffened one-piece unit which simplifies handling problems usually encountered during assembly operations. Primary applications of the process have been with Buna N rubber; however, other rubber or synthetic types would be equally suitable with selection of material depending on the operating temperatures, fluids to be sealed and related factors.

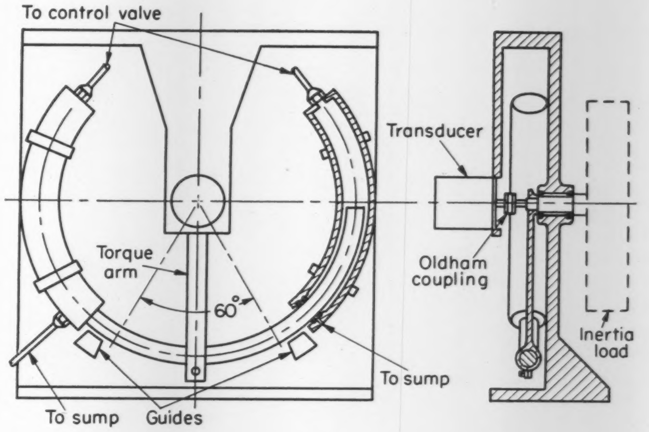


IDEAS

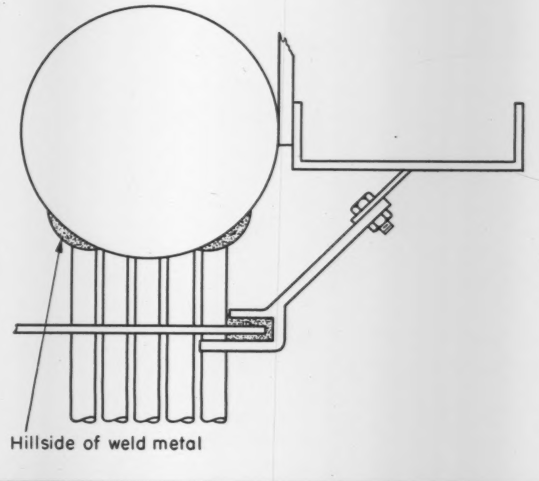


ANGULAR MOTION for accurate positioning or control movements is obtained with a hydraulic servomechanism designed by Professor James J. Ryan at the University of Minnesota. Especially suited to remote applications requiring power operation, the device employs a curved piston which is driven back and forth along a circular path by means of curved hydraulic cylinders mounted at each end. Torsional forces produced at the piston are transmitted to a shaft carrying the load by a torque arm free to move through an arc of 60 degrees.

In operation, piston position is controlled through a servovalve which is actuated by a signal to regulate the flow of hydraulic fluid to and from both cylinders. Control accuracy is assured by a transducer coupled to the load shaft which acts as a torsional sensing unit for feedback corrections. Although still under development, the design has been successfully tested in model form and offers a number of possibilities as a servo-positioning mechanism with an application range between the lightweight electric devices and the heavier hydraulic systems.

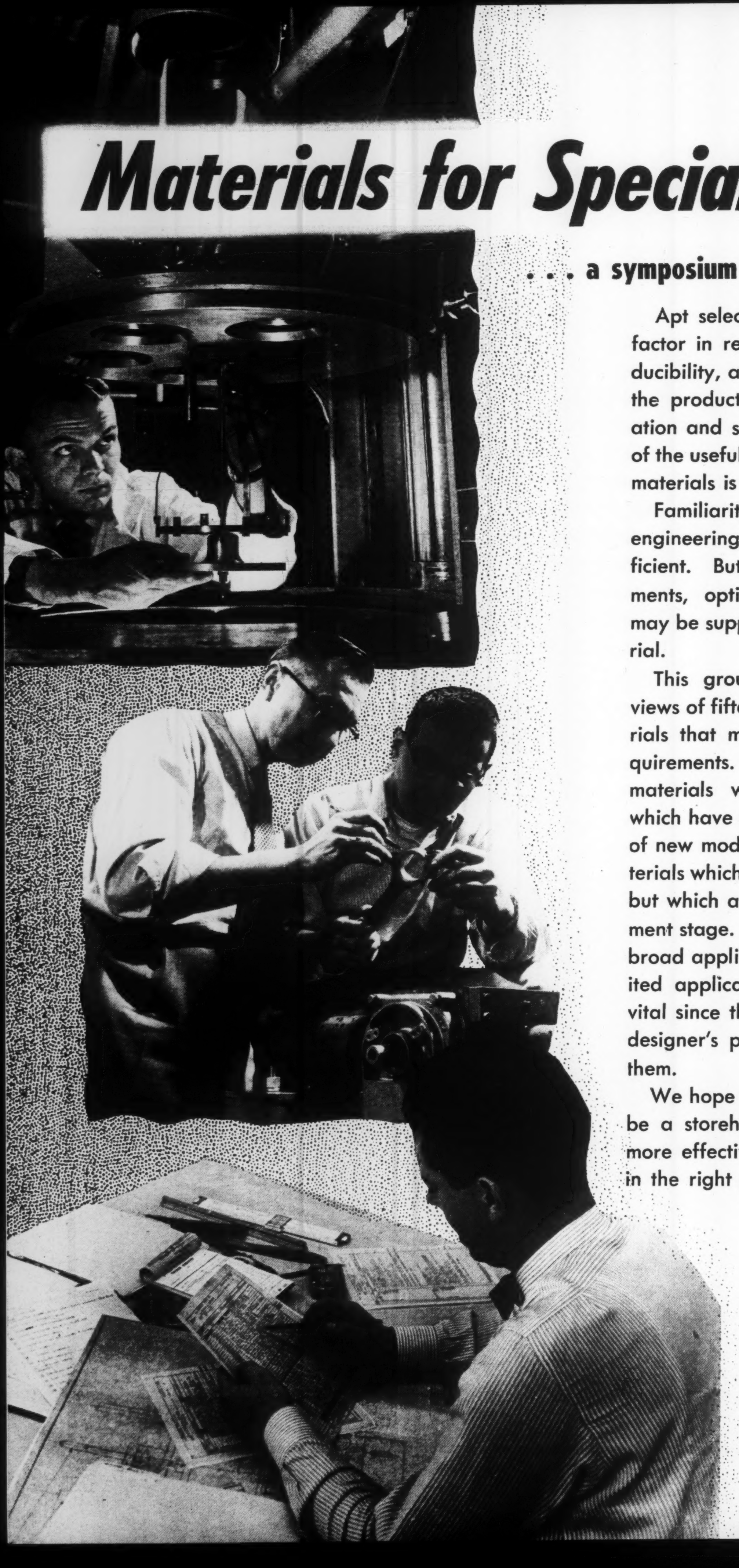


WELD METAL BUILDUP of circular header surfaces minimizes curvature effect and reduces fabrication and tube assembly problems. Suggested in the Bureau of Ships Journal as recommended design practice for superheater headers, the use of mounds of weld metal increases the usable width of tube seats and facilitates parallel mounting of tubes in banks.



Materials for Special Service

. . . a symposium of ideas for designers



Apt selection of materials is a major factor in reducing cost, increasing producibility, and improving appearance of the product. And for qualified evaluation and selection, constant awareness of the useful potentials of *all* engineering materials is required.

Familiarity with the common types of engineering materials is sometimes sufficient. But for certain design requirements, optimum service characteristics may be supplied only by a special material.

This group of articles presents the views of fifteen or so specialists on materials that may satisfy these critical requirements. Some of the articles tell of materials which are well-known, but which have increased usefulness because of new modifications. Some tell of materials which have high design potentials, but which are still in the early development stage. Some of the materials have broad application. And some have limited application, but are all the more vital since they can be the answer to a designer's prayer if he is familiar with them.

We hope this symposium will prove to be a storehouse of practical ideas for more effective use of the right material in the right place.

Photos, courtesy (top) Ford Motor Co., (center) D. W. Onan & Sons Inc., (left) Designers for Industry Inc.

Small and large-run production of electrical and mechanical assemblies can often be speeded with . . .

CASTING PLASTICS

By John R. Charlton *Manager, Plastics Div.*
Ciba Co. Inc., New York

USE of plastic casting resins has expanded considerably since new resins made the fabrication of large shapes possible in economical molds. Newer production techniques and new machinery have made casting methods more applicable to mass production, and the advent of television has made potting necessary in electrical equipment to a much larger extent than in pretelevision days. In potting, which has always been used principally for electrical apparatus, very great strides have been made, and equipment containing several thousand pounds of resin is being regularly manufactured. The mass production of small potted parts, such as servo and fractional horsepower motors, has recently begun on a large scale, and potting appears about to expand to a previously unimagined degree.

Materials used for potting range from the relatively low-cost asphalt and polymerized oil resins to the newer epoxy materials which have made a considerable advance in casting techniques possible. Asphalts and tung-oil resins have been used for a considerable time, but their use has been limited by their properties. They are so well known that the resins discussed in detail will only be those which show a degree of versatility that makes them useful in more than just a few applications. The chief plastic resins available for cast-

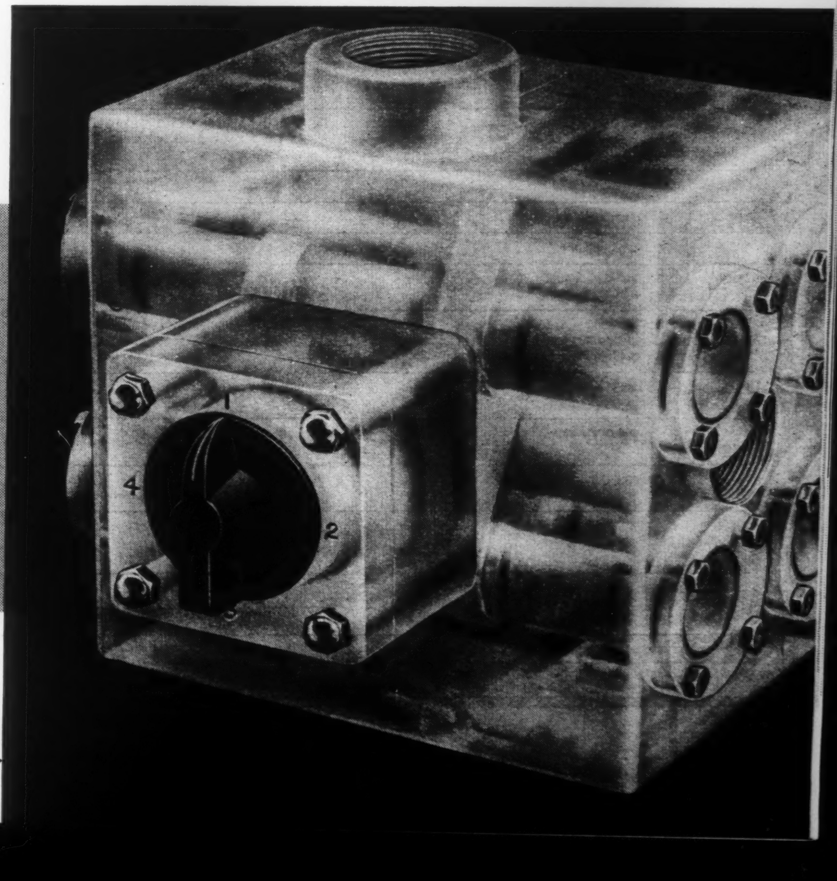


Fig. 1—Cast acrylic plastic body, used in this Cycloflow valve for chemical resistance

Photo, courtesy Rohm & Haas Co.

ing and potting today can be divided into five groups: the acrylics, epoxies, cellulosics, phenolics, and the polyesters, TABLE 1.

Acrylics: The acrylic resins are noted for their water-white transparency and, consequently, are generally chosen where optical qualities are important, such as cast plastic lenses. These materials possess good electrical properties and are used for oscillator coils and spacers, spreaders, etc. An interesting use for these resins is the embedding of biological and metallurgical specimens. The cured resins are characterized by dimensional stability, chemical resistance and weathering but, being thermoplastic, are not resistant to very high temperatures. They are also limited to the embedding of small parts and are not used to any extent in large castings because their shrinkage on solidifying is rather high, and the consequent strains lead to crazing and cracks. Large parts are, however, made by fabricating them from cast acrylic parts and bonding these together. A cast acrylic pump part is shown in *Fig.* 1.

Epoxies: The epoxy resins have come into prominence recently as engineering materials suitable for a large proportion of industrial casting requirements. Possessing the outstanding properties of high strength, rapid solidification, dimensional stability, and low shrinkage, they are a clear amber color and are not used for optical purposes, except in very expensively purified, colorless formulations. Their electrical properties at low frequencies are excellent and are maintained over a wide temperature range, and on this account they are used for potting transformers, etc. The resins are supplied as low or medium-viscosity liquids or low-melting solids. They possess the unique property of hardening without the formulation of side products and, therefore, produce strain-free castings that are tough and readily machinable. They can be supplied with varying degrees of hardness, from rubber-like materials to resins suitable for stamping steel sheet.

Epoxy resins are cured with organic acids or with organic alkaline materials which combine with the resin and are not catalysts in the customary sense. They form thermosetting compounds which have good heat stability at temperatures up to 150 C and higher if fillers are used. Catalysts are available which will cure the resin in a few seconds to a few days. Some catalysts require heat to cure the resin, but have the compensating advantage that they do not develop a highly heat-generating (exothermic) reaction, and can be used to provide catalyzed resins with a long shelf life. The largest castings now made have used acid-catalyzed systems because of the exothermal problem with the self-curing alkaline catalysts.

The great versatility of these resins has in-

Table 1—Comparative Properties of Casting Resins

Property	Acrylic	Epoxy	Phenolic	Polyester	Cellulosic
Available forms	Thin liquids and solids	Thin liquids and pre-catalyzed solids	Thin liquids	Thin to heavy liquids	Solids
Type of resin	Thermoplastic	Thermosetting	Thermosetting	Thermosetting	Thermoplastic
Appearance	Clear transparent, colorless	Clear amber	Clear amber	Clear, colorless	Clear, colorless to amber
Surface condition	Excellent	Depends on mold	Depends on mold	Open air surfaces poor (inhibition of cure), others depend on mold	Good—depends on mold
Reproduction of fine detail	Good	Good	Good, but sometimes shows fine cracks	Fair	Good
Types of service	Optical goods, chemical equipment	Electrical equipment, potting dies, chemical equipment	Foundry patterns, models, molds	High frequency electrical equipment, chemical equipment	Jigs, dies, tool handles, high-impact castings
Shrinkage on cure (%)	12–15	0.5–3	5–10	5–15	<1
Specific volume	23.2–23.4	22–24	20–22	19–25	20–22
Tensile strength (psi)	7000–8000	10,000–12,000	6000–9000	6000–10,000	2000–8000
Impact strength, Izod (ft-lb/in. notch)	0.4–0.5	0.5–1.7	0.2–0.4	0.2–0.4	0.4–8.0
Linear coefficient of thermal expansion (in./in./deg C $\times 10^{-5}$)	9	6	6	9	15
Heat distortion temperature (F)	150	220	170	250	110
Resistance to continuous heat (F)	160	300	175	400	220
Volume resistivity (ohm–cm)	10^{15}	10^{17}	10^{12}	10^{14}	10^{13}
Dielectric constant,					
60 cycles	3.5	3.8	6.5	3.0	3.0
10^6 cycles	2.7	3.6	4.0	2.8	2.8
Dissipation factor,					
60 cycles	0.05	0.001	0.1	0.003	0.005
10^6 cycles	0.02	0.019	0.04	0.006	0.010
Water absorption (%)	0.4	0.1	0.3	0.3	1.8
Machinability	Fair	Excellent	Excellent	Good	Good

creased demand very rapidly and, until this year, production was consistently behind the available market. Now that supplies have caught up with present requirements, the resins are freely available from at least three suppliers, and it is not likely that the resin will again get badly out of balance with demand. Cost has also shown a steady drop. In the first part of 1953, the liquid resins were selling at $1.50 per pound, and by the end of the year they had fallen to $1.00 per pound; the solid resins had declined in price from $1.00 per pound to $0.71 per pound. It is expected that the resins will become even lower in price as new plants now being built are put into operation. Pound for pound, this price is high when compared with the next largest selling resin, the polyesters, but the extra strength, stability, adhesive qualities, and lack of shrinkage have proved to be worth the extra cost.

Epoxy casting resins fall into two service categories, the electrical casting grades and the mechanical materials. The electrical grades generally are acid catalyzed because the electrical properties produced are more stable at high temperatures, but important improvements in amine catalysts have appeared recently. TABLE 2 gives properties for a typical electrical grade epoxy resin and shows that these materials do not take the place of high-frequency materials such as polyethylene or polystyrene but, instead, are chiefly used for electrical power equipment.

The large current transformer shown in *Fig. 2* is a typical use where the resin is cast around the winding using a vacuum chamber for best impregnation. The resulting core exhibits a stability not previously obtainable. The epoxy resin bonds to the metal parts and prevents moisture from creeping down the leads of the transformer. The fluidity of the resin reduces occurrence of voids, and the resulting casting resin exhibits very high corona resistance. This type of construction has never before been available in such large sizes of transformers.

In contrast to the electrical grades, the mechanical grades of castings are generally alkaline (amine) catalyzed because heat curing of the resins is not always practicable. Whenever very large castings are required, however, heat of reaction of an amine-catalyzed system may be great enough to destroy the resin and prohibit its use. On this account, very large dies for stamping sheet metal which may weigh up to 1000 pounds and more are frequently made with acid catalysts. These dies have been used successfully in stamping automobile body subassemblies and have produced more than 50,000 parts without wear. Because of the

Table 2—Typical Properties of Electrical Grade Epoxy Casting Resin

Physical Properties	
Shrinkage during cure, unfilled (%)	0.5–2.5
filled (%)	0.25–1.25
Tensile strength (psi)	12,000
Compressive strength (psi)	16,000
Impact test, Izod (ft-lb/in.)	0.69
ASTM* (ft-lb/in.^{2})	4.29
Hardness, Rockwell M	98
Vickers	20–24
Flexural strength (psi)	18,000–19,000
Water absorption (%)	0.14
Flammability (in./minute)	0.84
Heat distortion temperature (C)	109
Modulus of elasticity (psi)	450,000
Specific gravity uncured resin	1.210
hardener	1.505
cured resin	1.23
Coefficient of linear thermal expansion (in./in./deg C)	4.77×10^{-5}
Same, with high percentage of filler	2.5×10^{-5}
Ash content (%)	0.45
Electrical Properties	
Dielectric constant, at 60 cps	3.89
at 10^5 cps	3.65 ± 0.07
at 10^{10} cps	3.01 ± 0.06
Dissipation factor, loss angle tangent, at 60 cps	0.0051
at 10^5 cps	0.011
at 10^{10} cps	0.022
Volume resistivity, megohm-in.	$>2.3 \times 10^8$
ohm-cm	$>5.9 \times 10^{14}$
Surface resistivity, megohm	$>3.8 \times 10^7$
Dielectric strength, ⅛-in., short time (v/mil)	405
(kv at puncture)	50.2
step-by-step (v/mil)	380
(kv at puncture)	46.7
Arc resistance† (sec)	50–180

* ASTM D256-47T. † Burns on failure.

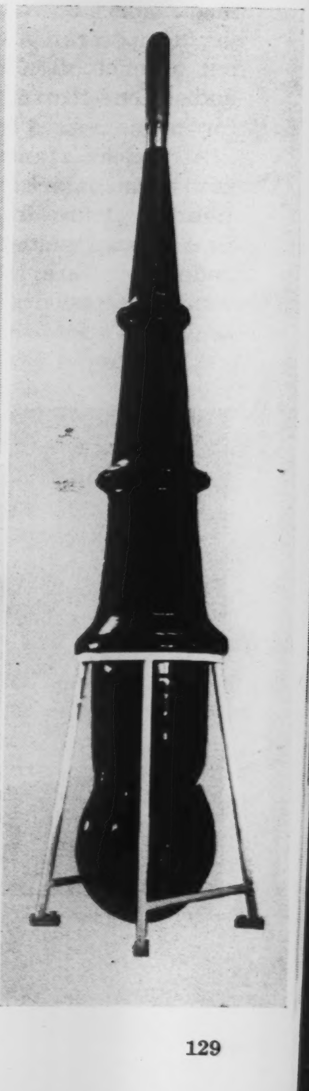


Fig. 2—Right—Large current transformer, vacuum-cast in epoxy resin for thorough impregnation of windings

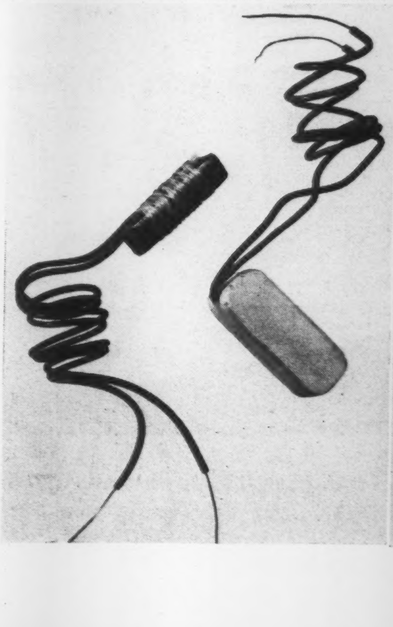


Fig. 3—Below—Phenolic resin is used for potting an electrical coil

Photo, courtesy Marblette Corp.

ease in making the castings, this method of producing a forming or stamping die should find a more important place in the future.

Largest use of industrial castings at present is in the automotive industry for the production of trim frames or match plates. These are exact replicas of the original model of the part to be made and are used to check the metal dies that are made for forming the final automotive part. Dimensional stability, therefore, is the most important criterion and epoxy resins have displaced almost all other resins for this application.

Present production methods for producing cast embedments in the electrical industry require metal or plastic molds for large production runs. Epoxy resins adhere tenaciously to most materials, and the mold must be made of polyethylene, Teflon or a silicone-coated metal. In the manufacture of impregnated servomechanisms and other small parts, an interesting production method is first to mold a polyethylene mold, assemble the motor in this mold, and then cast the epoxy resin. This method of production is limited to small parts having about a pound or less of resin because the heat of reaction may cause damage to the polyethylene mold. It is also limited to long runs of a standard product because of the expense of molding the polyethylene dies. Teflon molds, or Teflon-coated metal molds, on the other hand, will stand the baking temperatures of the acid catalyst systems, but are not often used because of their expense, and silicone-coated metal molds are most often used for medium-sized runs.

A typical example of the production method used to manufacture a trim frame: In the production of trim frame, the wooden pattern is first coated with a silicone parting compound and the pattern is then surrounded by the flask, usually a wooden frame reinforced with cross braces of glass-fiber reinforced plastic sheeting. Into this cavity a mixture of epoxy resin and catalysts with a very high proportion of a low-density filler, such as perlite, is poured. After the material solidifies, the finished trim frame is removed from the pattern. In the case of forming dies, the technique is quite similar, but the mold must be made of metal, and the resin usually consists of epoxy resin and acid catalyst, with a silica and glass fiber filler.

At the present time methods of production for epoxy resins are undergoing a rapid change because of the development of new catalysts and new equipment to handle them. When the resins were originally developed, working time, or pot life, of the mixed resin and catalyst was only an hour, and the hardening time was often several days. This difficulty has been worked on by the resin suppliers, and now pot life has been extended to several hours or even up to a day, and a new acid catalyst has been developed which gives a pot life of several days. Cure of these resins has been accelerated, and now may be completed in a short time at moderately elevated temperatures.

Equipment manufacturers have recognized the difficulty of weighing out separate amounts of catalyst and resin and then mixing where large production runs are required. There has, therefore, been a great amount of work done on the production of a dual metering and mixing device so that production of cast embedments in a process akin to injection molding could be achieved. This objective is most likely to be reached this year or next, and it will result in a very large expansion of potting and encapsulating in the electrical industry, which has just discovered the benefits of embedding but is hampered by lack of economical production methods.

It is most likely that large power transformers will be manufactured with epoxy resin replacing the oil-filled type. Epoxy resins can be filled with

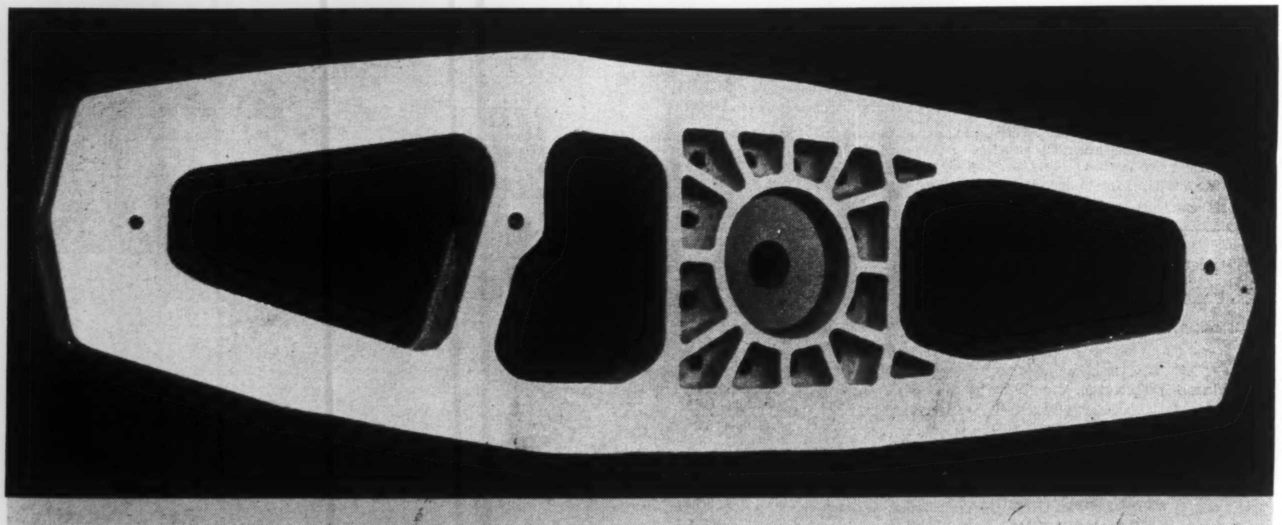


Fig. 4—Huge phenolic casting for an aircraft assembly fixture

a good thermal conducting material such as porcelain and, when cast around a transformer coil, provide a stable, trouble-free piece of equipment. In mechanical fields, epoxy resins will find increasing uses in tooling and metal die making. It can also be expected that line insulators and current breaker insulations will be made from this material when present tests are completed.

Cellulosic Casting Resins: Cellulosic casting resins, such as ethyl cellulose or cellulose acetate butyrate, are thermoplastic materials which exhibit outstanding impact resistance and dimensional stability. They are generally cast much like wax candles, by warming the solid resins up to a melting temperature (about 200 C) and pouring into the mold. At the melting temperature the resins are heavy liquids. These resins can be modified with waxes and fillers, etc., to produce a product corresponding to specifications.

The cellulosic resins have generally been used for jigs, form blocks, and gages. They have, to some extent, been eclipsed by the thermosetting resins such as epoxies which can offer liquid resins of greater versatility.

Phenolic Resins: Phenolic resins have been used for a considerable length of time in casting for tooling, for foundry pattern making and for manufacture of cast objects. The phenolic casting resins are thin or syrupy liquids which produce a yellow, transparent solid. They can be supplied as a self-curing resin, but generally a short heating cycle is used because superior castings can be obtained this way. They exhibit excellent pot life and can be cured in 7 to 24 hours, depending on the accelerator used.

Phenolic resins are seldom used for large embedments on account of the strains that result because of the shrinkage during cure. Great advances have been made in this respect, however, and phenolics may see increasing use for a limited number of embedding uses. The type of catalyst used is generally a mineral acid or an acid salt, and since this accelerator, unlike the epoxy catalyst, remains uncombined in the resin, the resultant acidity often prevents the resin from being used for potting of metallic parts. Potting resins are available to meet U. S. Spec. MIL-T-5422; *Fig.* 3 shows a potted coil in Marblette phenolic resin. After solidification phenolics tend to continue to cure over a long period of time. This tendency prevents their use for molds or dies where very accurate dimensions must be maintained over a year or so. In addition, the resins tend to develop surface cracks if the shape of the casting is intricate. Electrical properties are not outstanding and generally, if electrical properties are important, an epoxy or polyester resin is given preference.

The great length of time that phenolic casting resins have been available indicates their usefulness, and is an indication of their ready availability and the economy of using them. The prices for these resins generally are among the lowest of the casting resins and have been around 50-60¢ per pound during the past year.

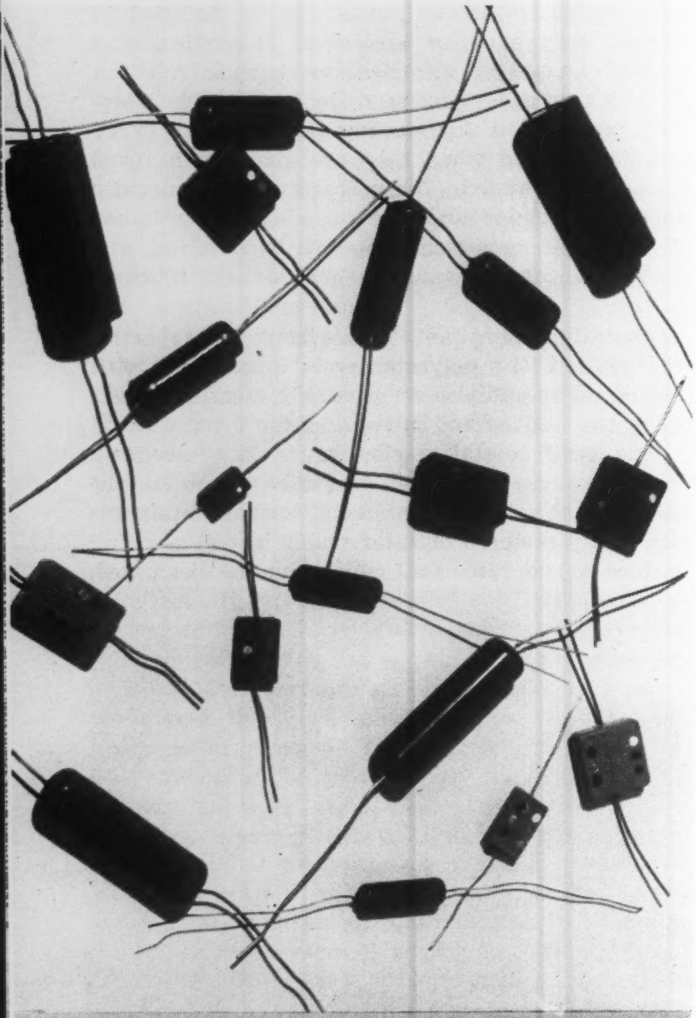
Phenolic casting resins have reached a more or less stable place in the industry and are generally used for dies or molds where tolerances and low impact strength are not too important. These resins were originally used for forming dies in metalworking, and *Fig.* 4 shows the resins used as a fixture for aircraft assembly, but their use in such applications is being superseded by the cast epoxy resins.

Polyester Resins: Until the advent of epoxy resins, the polyester casting materials were probably the most important resins for embedding, and their use in electrical work and elsewhere has shown a very large increase paralleled by the epoxy resins. Polyester resins can be modified to provide very superior electrical properties, and for high-frequency electrical work they fulfill a use which no other casting resin can provide. Polyester resins used for casting generally are very thin liquids, and when they are about to be used a catalyst is added. These catalysts are usually organic peroxides and are added in very minor amounts. If consistent pot life is required, the amount of catalyst must be measured very carefully.

Generally, where very high electrical properties are required, the polyester resin is modified with styrene. The addition of styrene increases shrinkage of the casting and introduces the usual complications when metal parts are to be embedded. Therefore, as with other high shrinkage resins, the maximum size of casting is smaller than obtainable with epoxy resins. Polyester resins in polymerizing produce considerable heat which must be dissipated, and this can be troublesome in producing large castings. There are considerable advantages in processing operations with polyesters because resins with long pot life and short cure at elevated temperatures are available. Polyester resins do not, as a rule, exhibit as high strength as epoxy resins and are not used for mechanical applications such as cast dies, jigs, and fixtures to as great an extent as epoxy materials. The resins do not bond to metals, and where adhesion to metallic inserts is required, they are replaced with other materials. This lack of adhesion can be an advantage where large quantities of cast parts must be removed from metal molds quickly.

Polyester resins show the greatest diversity in composition of any group of resins; they range from alkyd-styrene copolymers, triallyl cynurate modifications, and from acryl-anitrile-polyester copolymers, epoxy modifications. Therefore, the range in properties is very great, and suppliers are able to almost tailor a resin formulation to the user's requirements; thus it is very difficult to generalize on the properties obtainable. The triallyl cyanurate resins exhibit outstanding thermal stability, and the saturated polyesters show very good chemical resistance. Modifications are obtainable either clear, translucent, or in a variety of colors, and cast allyl resins have been used in optical lenses. Polyester resins are used in manufacture of jigs, dies, in chemical equipment and in potting electronic components. *Fig.* 5 shows typical applications for a polyester casting resin.

Designing for Potting and Casting: In designing for potting or embedding, the design must take into account the physical properties of the resin as much as the mechanical and electrical capabilities. It is difficult to choose a resin from a table of properties for an electrical potting job, because the casting process requirements of the resin may prohibit its use. If the casting contains large metal parts, such as transformers, and if it has to pass severe thermal shock requirements, the resin will most certainly have to be modified to provide some degree of elongation, and it may also have to be highly filled with a low-shrinkage filler to reduce shrinkage strains. Almost invariably the shrinkage of the resin during cure will be a major consideration, and if the resin requires high-temperature curing, the extra shrinkage caused by cooling from the elevated temperature will introduce additional strains. Large metal inserts should not be placed near the surface of the casting so as to produce areas where the metal is covered with a thin skin of plastic, or the shrinkage will cause cracks. There must not be large changes in section of the plastic, and the embedded parts should be placed as symmetrically as possible in the casting. If glass tubes are to be potted, they almost always must be enclosed in a resilient material to reduce the compressive stress, which can be strong enough to crack the glass. Avoid sharp edges and abrupt changes in strength.



Photo, courtesy Celanese Corp. of America

Fig. 5—Electrical and electronic components potted in polyester casting resins

Where plastic cast parts are to be made for severe service, such as forming dies, glass fiber reinforcement and fillers to provide abrasion resistance are usually required. Good fillers also increase the compressive strength, and the dimensional stability of the resins if properly chosen.

Where long runs are desired, or where very accurate castings are to be made, metal molds are necessary. Very accurate castings can be made if careful control of casting temperatures, mold temperatures, and curing conditions is exercised. One custom caster can produce epoxy castings accurate to ±0.0005-inch over a diameter of 4 inches if the occasion warrants it. Generally, however, the expense of such precision is greater than the value of the accuracy, and tubes and rods are more often centerless ground where critical tolerances are required.

For most purposes, chrome-plated steel molds are recommended, and where epoxy resins are used, silicone release agents are necessary. Impregnated plastic molds are customarily used for phenolic foundry patterns because of the expense of steel molds for short runs, and elastomer molds are used for almost all the casting resins for noncritical parts. Where intricate cores must be used, an alloy of lead and bismuth may be used to form the core, and a resin which cures below the melting point of the alloy, such as Araldite CN-501 epoxy resin, may be used. After curing, the resin may be heated to the melting point of the metal, and the metal can be poured out. This method of production has been used to a limited extent, and promises to be used much more so in the future.

It is expected that the designers of weighing and measuring machines will develop adaptations of their products to provide suitable equipment for automatic production of castings. At present there are satisfactory machines which will weigh out either uncatalyzed resins or catalyzed resins with long pot life at a rapid and satisfactory rate. When these machines are attached to an automatic conveyor system, potting can be done in a manner almost akin to injection molding. At present there are no machines which are able to measure catalyst and resin separately, and mix them just before injecting them in the mold. If such a machine were available, very fast-acting catalysts for epoxy resins could be used which would cure in a few seconds. With such a system, automatic potting of fractional horsepower motors would be very practical. Present machines are so close to this desired system that it seems very likely this system will be developed in the near future, and that it will revolutionize the potting and casting industry.

High heat and wear resistance, mechanical strength and insulation characteristics are provided by modern . . .

HIGH-ALUMINA CERAMICS

By Daniel W. Luks *Chief Engineer*

Frenchtown Porcelain Co., Frenchtown, N. J.

MODERN ceramic bodies are today applied in an amazingly wide variety of uses—applications which even relatively few years ago were not considered possible. At the turn of the twentieth century the rapidly growing electrical industry called for insulators which, at that time, were compounded much the same as pottery and dinnerware. In the era encompassing World War I and about 15 years thereafter a few innovations came about, notably the perfection of steatites and special heavy-duty spark plug insulations. However, it was not until the advent of World War II and the period immediately after when it was realized that entirely novel types of ceramics could be made to perform duties previously thought impossible.

Ceramics of high and controllable electrical capacitances were made from titanates. Ceramics

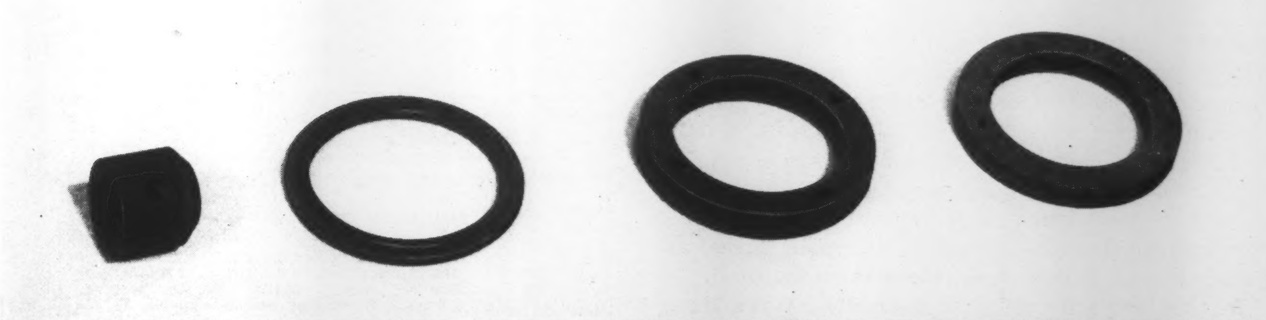


Fig. 1—Mechanical strength and resistance to chemical attack are two outstanding properties of high-alumina ceramics utilized for spray nozzles and rotary shaft seals

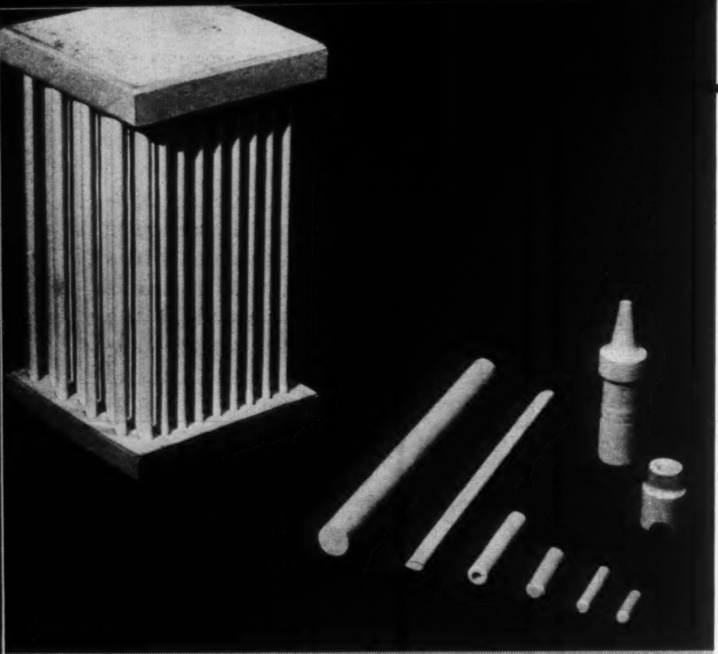
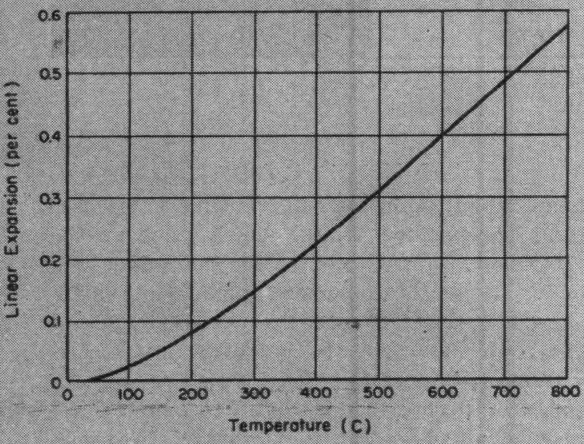


Fig. 2—Above—Excellent temperature and thermal shock resistance of the high-alumina compositions finds natural application in catalytic supports, high-voltage insulators and resistor bases

Fig. 3—Below—Linear thermal expansion of ceramic containing 95 per cent alumina



having no expansion upon the application of heat were developed. It was found that metals could be permanently protected from extreme temperatures by firmly fused refractory ceramic coatings. Metals and ceramic compounds were fired together to form cermets having properties new to the parent materials. Also "pure oxide" ceramics having phenomenal mechanical strength, in some cases as great as that of cast iron, were manufactured.

In the last group, the high-alumina types have gained much favor due to the readily available supply of high-grade corundum necessary for their formulation, along with their inherently desirable properties. Since these compositions predominate in aluminum oxide (corundum), they assume the physical properties of that mineral. Compared to most other ceramic materials, alumina is very hard (9 on Moh's scale), extremely tough and strong mechanically, *Fig* 1, an excellent conductor of heat, *Fig.* 2, resistant to chemical corrosion, and finally a superior electrical insulator at both high and low frequencies.

At first thought it would seem logical to form 100 per cent alumina bodies since the properties sought are those of the alumina itself. However, alumina is a most refractory material requiring extremely high temperatures for ceramic reaction. As a result, in actual practice, clays and other mineralizers are added to the alumina to bring about complete vitrification at appreciably lower temperatures. Also bodies approaching 100 per cent alumina are difficult to fabricate into shapes, adding to their cost of manufacture. Thus a high percentage of the alumina ceramics produced today contain about 75 per cent alumina and are ideal for low-cost items not requiring maximum properties.

Properties: In TABLE 1 are shown the electrical and physical properties of three commercially produced alumina ceramics. These are identified by their alumina contents. Briefly, their mechanical strength, thermal conductivity, and electrical properties improve in direct proportion to the quantity of aluminum oxide present.

Also, in *Figs.* 3, 4 and 5 are shown more detailed data on a ceramic containing 95 per cent alumina;

Table 1—Properties of High-Alumina Ceramics

Property	79% Alumina	88% Alumina	95% Alumina
Type of body	Alumina-mullite	Alumina	Alumina
Color	White	White	Brown
True specific gravity	3.33	3.61	3.88
Bulk specific gravity	2.97	3.44	3.52
Weight, lb/in.^{3}	0.107	0.124	0.127
Water absorption, %	0	0	0
Pore volume, %	10.9	4.7	9.3
Linear coefficient of thermal expansion, per deg C,			
25-100 C	4.40×10^{-6}	5.33×10^{-6}	3.60×10^{-6}
25-400 C	5.72×10^{-6}	6.85×10^{-6}	6.11×10^{-6}
25-700 C	6.42×10^{-6}	7.42×10^{-6}	7.29×10^{-6}
Coefficient of thermal conductivity, cal/sec/cm^2/cm/deg C	0.0095	0.0144	0.0180
Softening temperature, F	3000	3580	3500
C	1649	1971	1927
Tensile strength, psi	10,650	13,230	15,510
Compressive strength, psi	120,500	144,400	187,100
Flexural strength, psi	28,300	29,200	36,070
Impact resistance, Charpy,* lb-in.	5.1	5.8	6.2
TE value,† F	1310	1380	1470
C	710	749	799
Volume resistivity, meg-ohm/cm^3, 400 C	133	220	195
500 C	25	34	53
600 C	4.7	7.0	14.4
700 C	1.3	1.8	3.8
800 C	0.4	0.6	1.0
Dielectric strength, v/mil	200	203	202
Dielectric constant, 10^6 cycles	7.0	8.4	9.2
Power factor, 10^6 cycles	0.0014	0.00086	0.00035
Loss factor, 10^6 cycles	0.010	0.007	0.003

*½-in. diam rods between 4 in. centers. †Temperature at which 1 cu cm of material has resistance of 1 megohm.

specifically, its rate of thermal expansion, electrical resistance at elevated temperatures, and dielectric properties at various frequencies.

Applications: Ceramics having the toughness and dielectric properties of the aluminas should have many applications, and such is the case. Probably their biggest use is in the form of automotive and aircraft insulation. Another application is in vacuum tubes where advantage is taken of their ability to take a high temperature metal coating, to which metal fittings can be subsequently brazed to vacuum tightness. In some cases, their high hardness and abrasion resistance are utilized to overcome wear, as in the case of textile thread guides, *Fig.* 6. TABLE 2 cites a few potential uses.

Design Limitations: Alumina ceramics, like other types, are shaped by machining or molding in the "green" or unfired state, after which they are subjected to a carefully controlled firing process requiring a matter of days for completion. During this latter process they diminish in volume until thermochemical reactions are finished, at which point maximum density of the ceramic occurs. Since they are fragile in the unfired, machined

Table 2—High-Alumina Ceramic Applications

Utilizing Electrical Properties

Insulators: support, ring (high-voltage equipment), magnetic relay
Printed circuit bases
Conductive ceramics
Condenser shafts
Bushings for Cottrell precipitators
Antennas: cavity, masts, housings (radomes)
Capacitors and resistor cores
Spark-plug insulation
Radio tube spacers
Hermetic seals
Waveguide windows
Envelopes

Utilizing Mechanical and Chemical Properties

Nozzles: hydrosilica cleaning equipment, and blasting. steam jet, spray-drying, spraying
Guides: thread, wire
Wear-resistant inserts
Pumps: plungers, casings, impellers, case plates, shaft sleeves for acid types
Valves: ball check, seats
Rotating-seal faces
Ejectors
Dies: tablet machines, ceramic products, paste products, plastic injection molding
Gages: thread, plug
Cutting tools

Utilizing High-Temperature Mechanical Properties

Jet engines: rotor and stator blades, target plates, combustion cans
Thermocouples: protection tubes, spaghetti
Inserts: recoilless rifles, rocket nozzles
Furnaces and burners: vacuum annealing tubes, atmospheric combustion tubes, rotary oil burner air nozzles, muffles, shaker hearth refractories, radiant tubes, burner plates, radiant cup burner refractories, kiln furniture
Brake liner for jet engines
Heat exchanger pebbles
Pyrometer tubes
Crucibles and retorts
Permanent casting molds

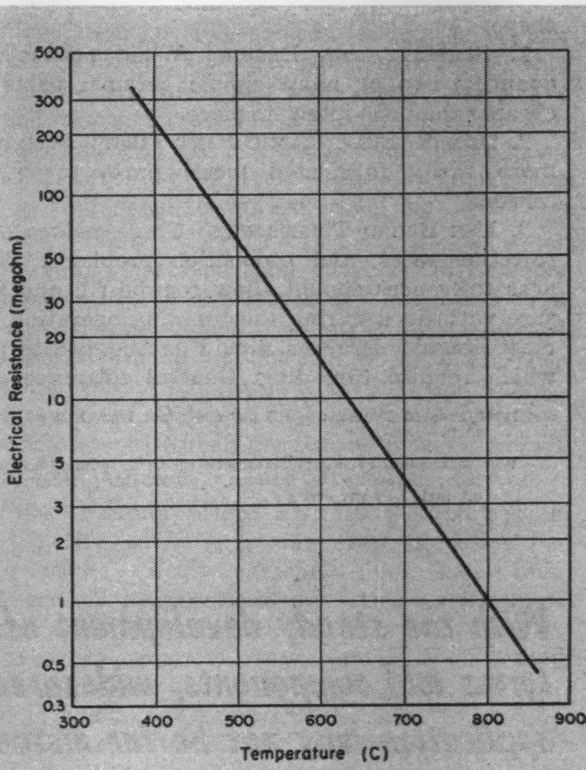


Fig. 4—Above—Electrical resistance of 95 per cent alumina ceramic

Fig. 5—Below—Dielectric constant and power factor of 95 per cent alumina ceramic at various frequencies

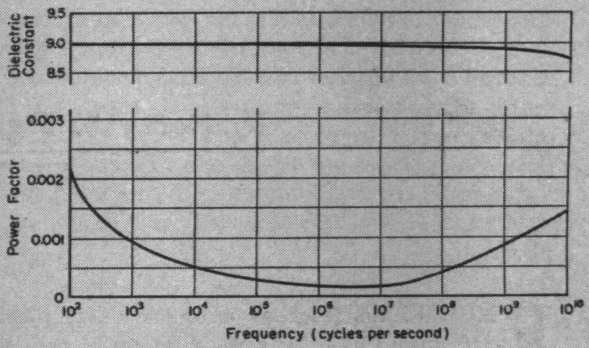
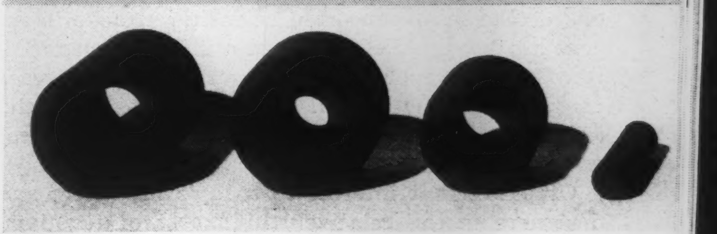


Fig. 6—Below—Use of high-alumina ceramics for wire and thread-guide bushings illustrates their abrasion resistance and mechanical strength



state and the firing shrinkage averages between 10 and 20 per cent of the fired size, a few simple rules should be followed in designing a ceramic shape.

1. SIMPLIFY THE DESIGN: When produced in quantity two or more simple ceramic parts are cheaper than one intricate piece.

2. DESIGN THE CERAMIC PART FIRST: Design the more easily fabricated metal parts to fit the ceramic.

3. USE BROAD TOLERANCES: These reduce costs, rejection rates, and production problems. Thickness tolerances should allow for die fill and pressure variations during the pressing operation. The most liberal tolerances should be assigned to parts which require threading. General tolerances are:

Dust Pressed Process: ±1.5 per cent; not less than ±0.010-inch.

Wet Extrusion Process: Diameters up to 1 inch, ±0.0010-inch; holes up to 0.1-inch, ±0.005-inch; holes over 0.1-inch, ±1 per cent.

4. MINIMIZE CROSS SECTION CHANGES: Also avoid thin walls if possible to reduce rejects due to warpage and cracking.

5. WATCH HOLE AND COUNTERBORE SPACING: Holes and counterbores should neither be placed too close together nor too near the edge of a part since this fosters structural weakness. A minimum number of holes and of holes at right angles to each other will reduce costs considerably.

6. INDICATE ALL SURFACES REQUIRING GLAZING: At least one surface must be left unglazed to facilitate firing.

7. ELIMINATE SHARP EDGES AND CORNERS: A slight radius or preferably a 45-degree bevel will greatly reduce chipping of the piece and increase the life of the die.

8. ALLOW SUFFICIENT CAMBER: Camber should be permitted for surfaces which are subject to warping during firing, such as flat plates and long narrow pieces.

With the steady development of techniques for the production of diverse forms and components, widespread commercial application may not be far distant for . . .

TITANIUM

By Harry S. Brenner *Bureau of Aeronautics*

Dept. of the Navy, Washington, D. C.

ENGINEERS familiar with the development of titanium have often expressed the view: "Titanium today is in the position aluminum was 35 or 40 years ago." Certainly its promise as an industrial metal is just beginning to be realized. Without question is the fact that titanium fulfills a definite design need, and this is one of the reasons why this new metal has been subjected to one of the most concerted scientific attacks in recent history in an effort to gain information necessary for its proper use. However, the final success of this new metal will be dependent upon the ability to produce and fabricate titanium economically.

Of paramount interest to today's producers and designers is the relatively high cost of titanium. While titanium is the fourth most abundant structural metal in the earth's crust, unfortunately it is not found in its pure state. Refining the available ores is expensive and to date has resulted in rather limited production based on the demands of the using industry. It is significant to note though that the prominent titanium refiners are expanding production to help meet the need, and it is expected that appreciably more titanium will be available from now on. Yet, widespread commercial use of titanium products will only result from a sharp decrease in the cost of the basic material.

Its almost prohibitive cost for commercial applications is perhaps one of the big reasons why the majority of research and development projects have been sponsored by the Government. The main reason for interest in this field, however, lies in the properties and characteristics of titanium itself.

Titanium as a structural metal has a very favorable strength-weight ratio; it has unusually high strength for its relatively low weight. In addition, its corrosion resistance characteristics are excellent, placing it in the same general class as the stainless steels. Titanium has a low coefficient of expansion and low thermal and electrical conductivity. It has a low modulus of elasticity, characteristic of light metals. It is paramagnetic.

Properties and Applications: With an understanding of these properties, it may be evident that its greatest advantage at present appears to be in applications sensitive to weight. Specifically in the field of aircraft, where a premium is paid for weight savings, does the use of titanium intrigue the designer, *Fig.* 1.

To date considerable effort has been exerted in the development of titanium sheet, *Fig.* 2 and its forming into various useful configurations for aircraft applications. Especially in the 250 F to 800 F temperature range is the strength-weight ratio definitely in favor of titanium as compared with aluminum alloys and corrosion resisting steels. The significance of this advantage can be realized from the fact that as aircraft of the future attain greater speeds, skin friction and consequent increase in skin temperature will become major design considerations. For instance, it is estimated that an airplane flying at twice the speed of sound at 35,000 feet will develop temperatures of 600 F at the skin.

Other prospective aircraft applications involve use of titanium forgings and fittings, and of recent interest, use of titanium structural fasteners such as nuts, bolts, screws, and rivets, *Fig.* 3. In view of the great number of fasteners used in airframe construction, the weight savings based on substitution of titanium alloy for comparable type steel fasteners assume major proportions.

One other area of prime aircraft interest involves use of titanium in engines. Its excellent performance in corrosive media is just as important as its strength-weight advantage. Parts such as compressor disks and compressor blades are being fabricated from forgings and bar stock, *Fig.* 4. Items such as shrouds and fire shields are being fabricated from sheet stock. And again, fasteners and miscellaneous hardware items are attractive as weight savers.

The full importance being attached to titanium as a structural metal is perhaps suggested in a recent airframe industry survey which indicated a potential future application of titanium constituting roughly 30 per cent of airframe weight. By comparison, current figures estimate that titanium alloys constitute 3 per cent of airframe weight in present design.

While titanium offers distinct possibilities in aircraft, its advantages have not been lost to other users. Army engineers long have been cognizant of its possibilities. Any reduction in weight which a soldier must carry into combat will result in a more effective fighting man. Thus, serious consideration has been given to use of titanium in armor and equipment in order to provide equivalent or better performance with weight savings. Similarly, with emphasis being placed on mobile equipment and airborne armies of the future, undoubtedly applications of this lightweight metal will be pushed.

As noted earlier, the corrosion resistance characteristics of titanium are excellent, especially in sea water and marine atmospheres. Accordingly, another field of research has involved applications of titanium in Naval vessels and on equipment subjected to marine environments. Titanium itself has held up especially well in sea water. However, based on tests of titanium coupled with other metals, it will be necessary to watch design applications carefully to assure that the mating materials will not be affected by galvanic action. Although it may eventually be desirable for installations such

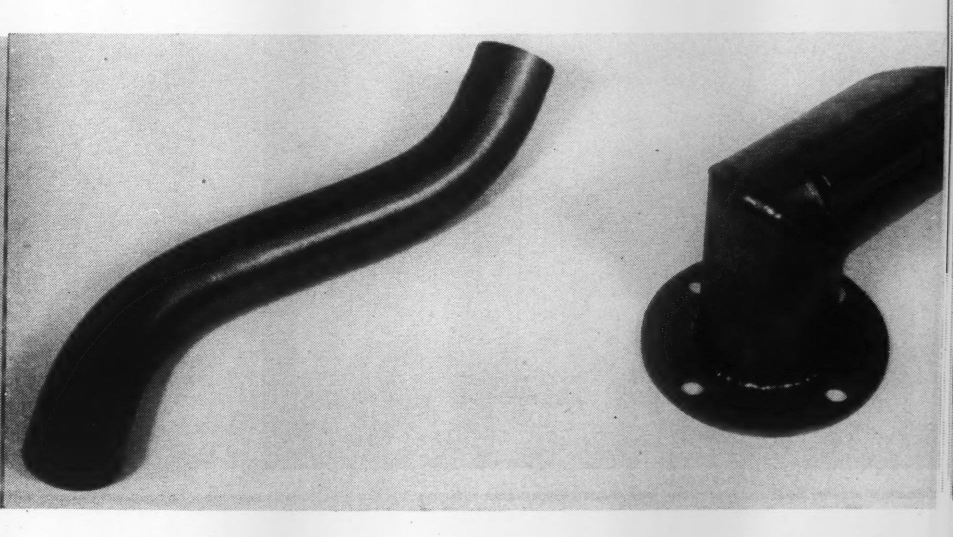


Fig. 1—Jet engine air ducting of titanium-alloy tubing

Photo, courtesy Rem-Cru Titanium Inc.

as salt water valves, condenser and heat exchanger units, mufflers, and equipment exposed to stack gases, any urgency to employ titanium is tempered by the high cost at present. At such time as titanium does become commercially attractive, it is certain that many other industrial applications will be investigated. In areas where good corrosion resistance properties are desired, uses would conceivably include medical and dental equipment, food handling and processing equipment, equipment subjected to highly corrosive chemical media, and sporting equipment, to name but a few. As a strong, lightweight metal, titanium would be of advantage in portable machine tools and equipment, personal safety equipment, machinery, orthopedic braces, and so on. And as an example of a high-temperature application, it may be used in superheated steam and similar systems. At this early stage in the development of this so-called "wonder metal," it is only safe to say that titanium is being examined by every major industry for possible service.

Production Design Aspects: Beyond the fact that titanium is now being recognized as useful for commercial purposes is the realization that data on techniques of fabrication have only recently become available. Even so, the state of the art is still flexible enough such that new information and methods of manufacture are eagerly being scrutinized by industry. Essentially titanium is available in two distinct classes: commercially pure titanium and titanium alloys. The commercially pure or unalloyed titaniums are characterized by yield strengths of approximately 70,000 to 80,000 psi, good ductility, relatively high fatigue strength, good corrosion resistance, and favorable strength properties through 800 F. Several commercial alloys have been introduced which have been used with success. It should be pointed out though that the full potential of various titanium alloys is far from being realized. However, for the alloys developed to date, yield strengths almost double those of commercially pure titanium are easily guaranteed. The alloys can be grouped into those developed for forging and those developed for sheet of flat-form applications. Ductility varies depending on the type of alloy used but the excellent corrosion resisting characteristics remain unchanged. The problems associated with the forming and fabrication of titanium have been of the greatest concern to industry. In this connection one source of difficulty is diminishing with production of higher quality and more uniform raw material. Formerly, serious complaints were registered over the inconsistent physical properties observed from lot to lot.

Considering commercial titanium sheet, its forming characteristics have been likened to that of $1/4$ to $1/2$ hard 18-8 stainless steel. Successful forming techniques include bending, spinning, drawing, stretch forming, cupping and other similar operations. While annealed sheet in thickness (t) to

Fig. 2—Rolling of 30-inch wide commercially pure titanium. Finished thickness, 0.020-inch; weight of coil, about 1000 pounds

Photo, courtesy Titanium Metals Corp. of America

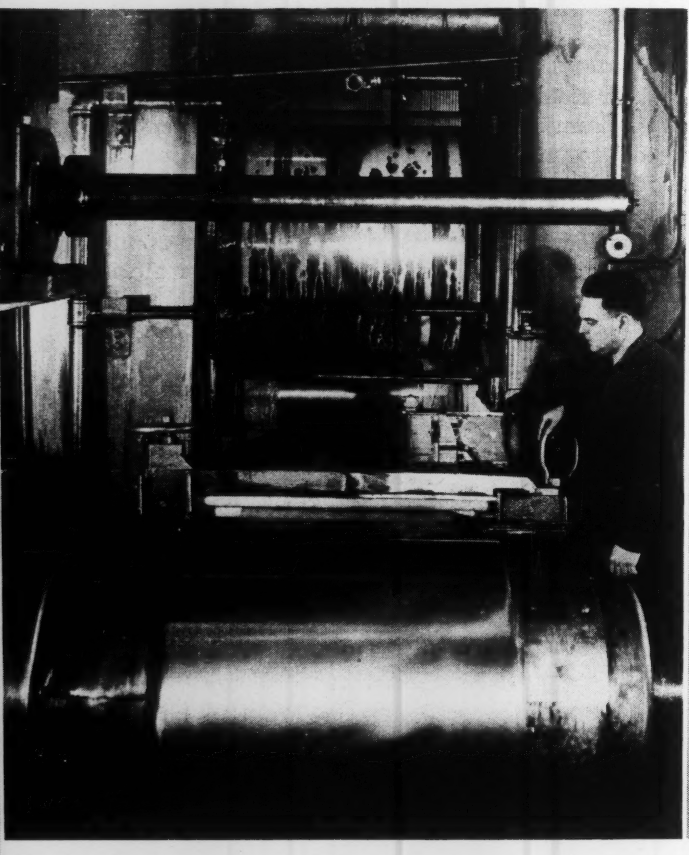
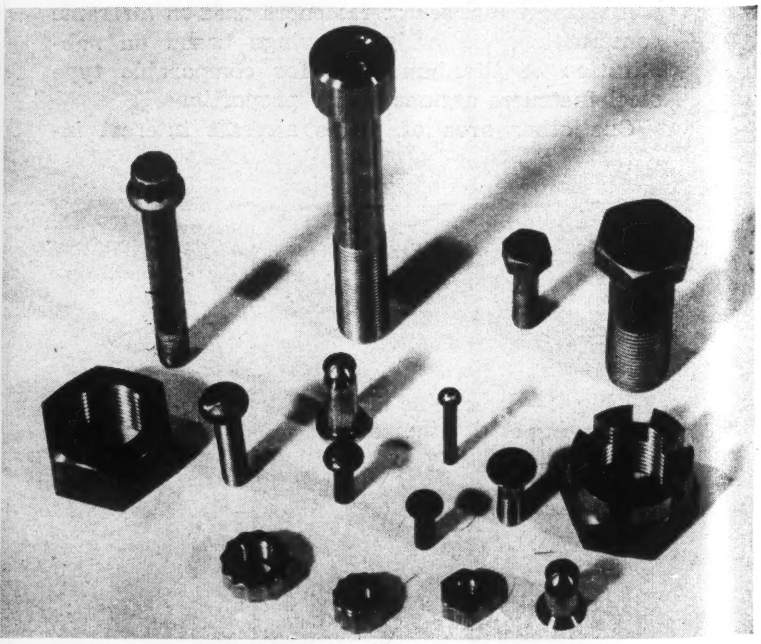


Fig. 3—Samples of aircraft titanium fasteners produced to date

Photo, courtesy U. S. Navy



0.070-inch can be bent cold on a radius of 1.5 to 2 t at 105 F and on a radius of 2.0 to 2.5 t for sheets greater than 0.070-inch standards for specific forming operations are still being developed and based on local experience. More generous radii (in the order of $5t$) are being used for room-temperature bending of half-hard sheet, but working the sheet at elevated temperatures of 500 to 700 F has indicated a noticeable increase in ease of forming. The average minimum bend radius for alloy sheet is between 1.5 and 3.0 t. Equipment standard for forming stainless steel can be adapted for titanium sheet with possibly slower press speeds. In the event of critical cold work during such forming operations, it may be necessary to anneal the titanium frequently to relieve these stresses.

No particular difficulty has been observed in forging titanium by standard means. It has excellent flow characteristics and gives sharp, clean die impressions. Forging temperatures of 1600 to 1800 F have been recommended since forging above 1800 F may result in scaling and surface hardening due to absorption of nitrogen and oxygen. Of interest are the results of recent investigations covering fabrication of threaded structural fasteners. Commercially pure titanium was headed at room temperature with relative ease. However, it was necessary to forge titanium alloy at temperatures of 1650 F in order to achieve a proper upset. Among other things, this investigation pointed up one of the serious shortcomings of this metal—its notorious galling and seizing characteristics. For high-speed production, a suitable lubricant will probably be required to alleviate galling. Some efforts have been made to copper flash coat commercially pure wire and rod, although some oil lubricants and molydisulphide may also be acceptable, depending on the setup.

Fig. 4—Titanium-alloy forged and machined compressor blades

Photo, courtesy Titanium Metals Corp. of America

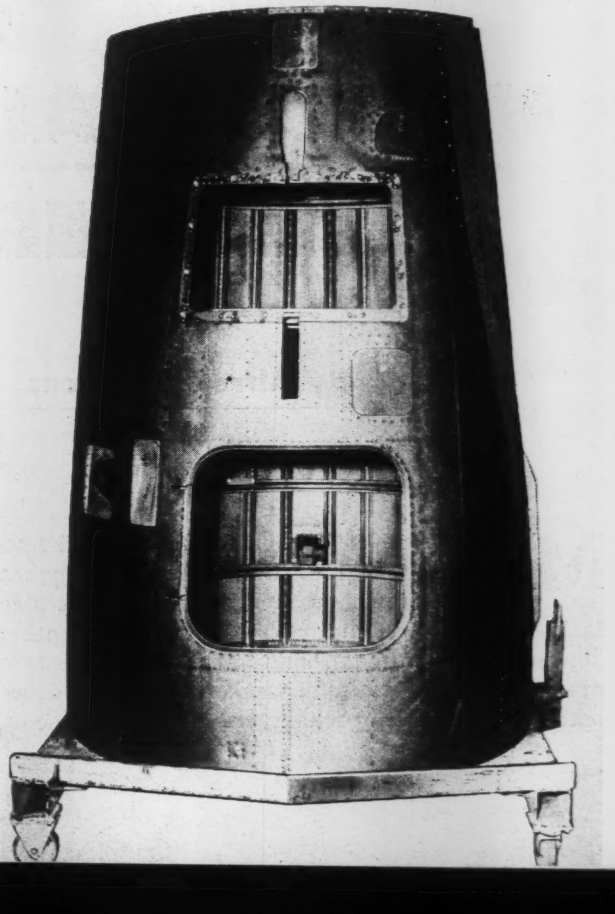
This problem, of course, introduces another. With the fabrication of threaded fasteners comes the problem of use of nuts and bolts in combination. Not only will a lubricant be required to manufacture the fastener, but in all probability, a thread lubricant will be necessary to assure its proper use. Some work with Teflon and other coatings, such as silver and rhodium plating, indicates that this approach may be the answer.

With respect to fasteners, no difficulty has been experienced in cold rolling threads in any of the alloys. However, the blank size must be adjusted to suit the ductility and hardness of the material.

Machinability of commercially pure titanium is similar to that of type 302 stainless steel. However, the titanium alloys are more difficult to machine and require more detailed attention. Due to

Fig. 5—Titanium nacelle for new Douglas DC-7. Skin is stretch formed at room temperature. Ribs and stringers are shaped in cross section by brake or roll forming, then stretch formed to proper longitudinal curvature. Both spot welding and riveting are employed in assembly

Photo, courtesy Rem-Cru Titanium Inc.



the galling characteristics and low thermal conductivity, heavy cuts and slow speeds have been recommended. High-speed tools and carbide-tip cutters are suggested for the various machining operations such as drilling, reaming, milling and turning. In particular, cutting tools should be very sharp to avoid the possibility of work-hardening and consequent chipping, burnishing and tearing of the metal. Drilling should be accomplished with short twist, high-speed drills and in order to avoid galling, the drill must be kept turning until the operation has been completed.

Use of proper lubricants is virtually essential in successful machining to eliminate or minimize the galling and seizing tendencies of titanium. Some notable effort has been expended in developing suitable cutting oils for this purpose, such as oils containing sulphur additives and oils to which chlorinated solvents have been added.

Grinding investigations have revealed that titanium and its alloys are difficult, but not impossible to grind. Due to the high rate of wear of grinding wheels, it is advisable that particular wheels be adapted to specific operations such as rough grinding, cutting off, and surface grinding. Aluminum oxide grinding wheels have proven successful. Under any circumstance, caution should be displayed since titanium dust, like that of other similar light metals, is explosive. Wet grinding can alleviate this shortcoming.

No difficulty has been encountered in inert arc welding, resistance flash butt welding, spot welding or seam welding, *Fig.* 5. Only care should be exercised to assure that titanium is protected from air contamination.

Titanium can be descaled and cleaned by both standard mechanical and chemical treatments. Scale can be removed by conventional grit or vapor blasting methods where a rough matte surface can be tolerated. For normal operations, scale can easily be removed by immersion in a standard sodium hydride bath followed by a water quench and a brief acid brightening dip in a ¼ per cent hydrofluoric acid, 10 per cent nitric acid pickling solution.

Of necessity, only highlights of titanium fabrication methods and their influence on design have been covered here. Titanium producers have accumulated much information of considerable value in specific situations and based on efforts to date, confidence in fabricating and using titanium is rapidly mounting.

Titanium itself may not be a general cure-all, but it definitely is to be recognized as a specific, useful industrial metal having distinct advantages, and drawbacks, and the promise of many fruitful applications. The effort already expended in the space of a few short years in the development of this metal and the results obtained are an indication of its bright future.

An old engineering material takes on new properties as chemistry adds to the versatility of . . .

MECHANICAL LEATHER

By Alfred S. Berens *Chief Leather Chemist*

Chicago Rawhide Mfg. Co., Chicago

MODERN use of leather for mechanical purposes dates from the early 1900's when chrome-tanned leather was used for clutch facings in the first automobiles. Numerous other applications were soon found in the form of leather protective boots, gaskets, washers, coupling disks, pads, and then as packing elements in oil seals. These applications are still common throughout industry today, *Fig.* 1. The majority of mechanical leather applications, however, are for oil seals and hydraulic and pneumatic packings, *Fig.* 2.

Properties which make leather desirable as an oil seal or packing are: oil and solvent resistance, flexibility, high tensile strength, low coefficient of friction. It can be readily formed into permanent shapes which withstand extreme pressures without cold flow, and it will withstand temperatures from −300 F to 250 F. It will not bond to metal unless desired, nor corrode it. Variation between static and kinetic coefficients of friction is small. Because of this, there is no tendency to chatter in hydraulic applications. There have been applications where leather packings have operated well over 200 million feet of piston travel, with over 200 million reversals without any measurable wear. Leather cup seals can be more than 98 per cent efficient in cylinders of 3-inch bore and larger for pressures of 80 psi and higher, with exacting tolerances and finishes. Leather has only a slight scoring tendency, particularly important on feeds and metering circuits where scored cylinder barrels cannot be tolerated.

Designing for the use of cup leathers rather than piston rings in various applications can effect considerable savings—savings originating from sealing efficiency. In one installation, leather cup piston seals and leather flange rod seals were used in approximately 75 cylinders with bore sizes ranging from 4 to 12 inches. A central system of 2500-psi and 38-gpm capacity, with an accumulator, supplied all the high-pressure oil required. A 400-psi, 150-gpm low-pressure centrifugal pump supplied the approach-stroke oil requirements. It was estimated that if piston rings were used a pumping capacity of 200 to 400 gpm instead of 38 gpm would be required. The cost of pumps alone would be estimated at $35,000 to $40,000 plus the cost of electricity and maintenance.

A frequent charge against the use of leather cup seals at one period was failure due to "cup pull-out." This was a condition where the cups were dislodged from normal position and contours distorted. However, investigation by hydraulic cylinder manufacturers showed primary cause to be improper design of component parts that support and hold the leather.

Traditional Fillers and Coatings: Until about a year ago, the chief disadvantage of leather in mechanical applications was its porosity, which permitted oil and other liquids to seep through it. The earliest attempts to fill leather involved the use of waxes—carnauba, montan, paraffin and many others. The result was reasonably impervious leather. Flexibility varied widely, however, and the wax filler was frequently soluble in oil. Once the melting point of the filler had been reached, heat and pressure washed it out. Wax-filled leathers remain widely used in industry today where moderate temperatures exist. They are very satisfactory in pneumatic applications operating near room temperature and with relative absence of oil.

Similarly, a wide range of coating materials have been used to prevent leakage through leather. Two major drawbacks are incurred. Cut edges of the leather are not sealed, which in some cases permits oil or gases to pass through the leather as if no coating were present. Even more serious in many applications is the condition where a completely impervious surface-coated leather no longer permits any lubricant to reach and lubricate friction areas.

New Impregnated Leather: The first work with synthetic resins, using them as leather impregnants, was done by dissolving them in a solvent, saturating the leather, then evaporating off the solvent. Impregnations based on this solvent impregnation process are being successfully used in the industry today. Far more significant are the newer treat-

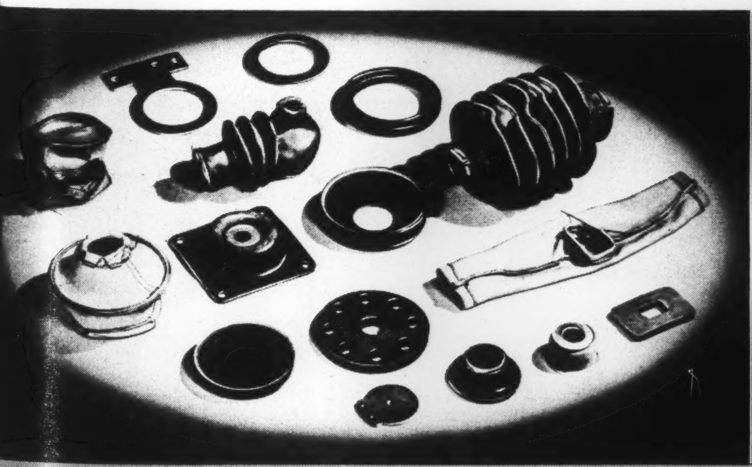


Fig. 1—Typical examples of mechanical leather parts include protective boots, packings, washers, gaskets, couplings, and valve disks

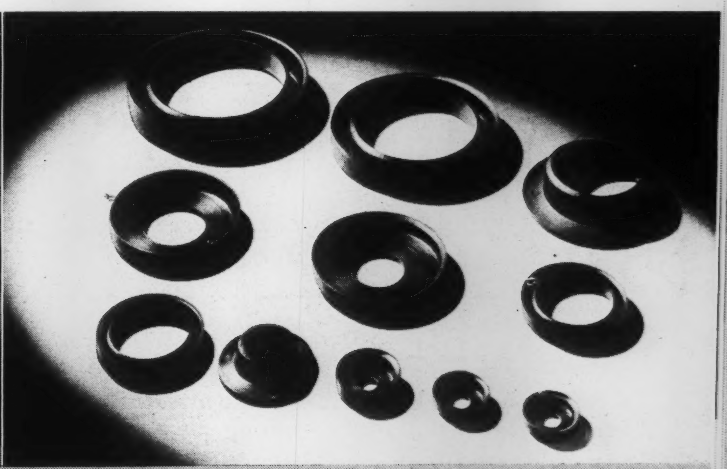


Fig. 2—Examples of cup and flange packings currently produced from the new impregnated leathers

ments wherein reactive monomers or low molecular weight, liquid resins are used for impregnation. After deposition in the leather, these liquids are converted to high molecular weight, rubber-like materials having excellent oil resistance and melting points, if any, far above any normal operating temperatures. Typical examples of these reactive liquid resins are the various acrylate monomers, vinyl monomers, low pressure laminating resins, and low molecular weight epoxides.

A number of mechanical leather packing manufacturers have carried research programs to the point where they are using polymerizable liquids in impregnants in production runs. In the main, their objective has been to produce leather packings with minimum porosity, to eliminate excess leakage and still retain the high mechanical strength, flexibility, or "snap" of leather and at the same time to increase the effective heat and solvent resistance. Several manufacturers have reached this objective with outstanding success.

One such development is the new Conpor material produced by Chicago Rawhide Manufacturing Co. Essentially, it is the impregnation of chrome retan leathers with Thiokol liquid polymers, followed by further polymerization within the leather. One advantage of the new material is that complete control of porosity is possible from 0 to 100 per cent (based on the leather's original porosity). Undesirable leakage can be eliminated entirely, but lubrication through the packing or sealing member may be closely controlled.

Properties and Test Findings: All advantages of leather have been retained—high tensile strength, flexibility, oil and solvent resistance, excellent abrasion resistance and high heat stability. Once the leather is treated, the new series of impregnations are so insoluble in oils and organic solvents they cannot be removed for examination. There is practically no change in volume upon oil immersion. Seventy-two hour tests resulted in 1 per cent swell in SAE 20 oil at 250 F and 1 per cent shrinkage in hypoid lubricant also at 250 F.

One of the important differences in the three modifications of this new material is porosity after impregnation. The treated leathers are not completely impervious to oil. They are designed primarily to eliminate objectionable leakage on shaft type oil seals while at the same time permitting lubrication at contact areas, thus reducing friction and wear to the minimum. In static permeability tests run on disks using SAE 10 oil at 4 psi an untreated leather leaked 179 grams of oil. The most porous of the three impregnated leathers leaked 3.2 grams in the same length of time. On other static tests using flange packings for sealing air pressure, untreated leathers were able to seal only 3 ounces per square inch, while the three impregnated modifications sealed an average of 13 psi, 60 psi and 100 psi.

From the laboratory viewpoint a 100-hour oil seal test is indicative of the quality of a leather impregnation, but tests of much longer duration must be run to establish complete suitability of that particular treatment. Consistently low leakage that may be expected from the new rubber-impregnated seals is shown in *Fig.* 3.

Field experience of a general nature obtained through the use of the impregnated leathers on all stock seals during an 18-month period, an almost equally large number used on original equipment installations, and hundreds of tests on a wide variety of equipment have established that the oil seals of the new combination materials are superior to other leather seals presently available.

The most porous of the three modified leathers is specifically recommended for standard shaft type

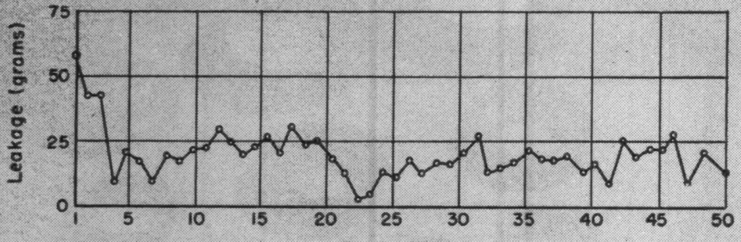
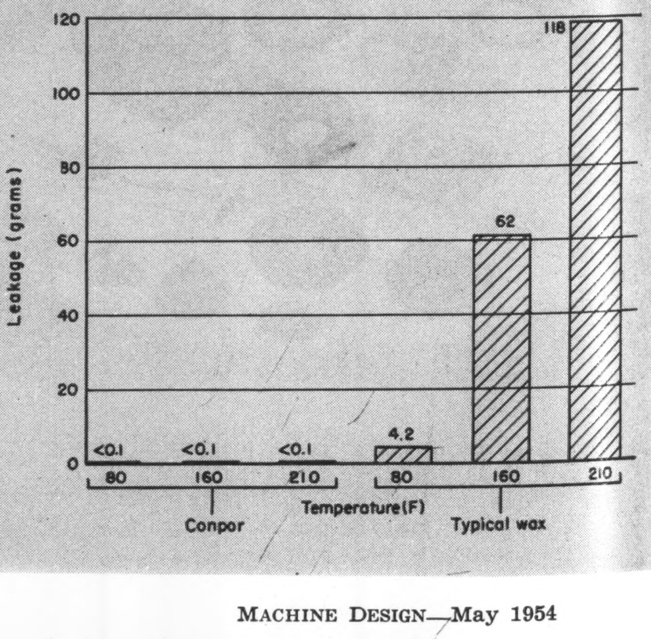


Fig. 3—Above—Daily leakage of ten seals of the new impregnated leathers running 20 hours per day with 2-inch shaft, 3-inch outside diameter, SAE 20 oil, 1200 rpm, 1 psi, 200 F

Fig. 4—Right—Average hourly leakage of new modified leathers and typical wax-impregnated leathers at 1500 psi, six cups, 2¼-inch diameter, with AN-0-366 oil



oil seal applications for oils of SAE 20 viscosity and higher, where objectionable leakage must be eliminated, but adequate lubrication provided at contact surfaces to insure long life.

The modified leather of intermediate porosity is suggested for low-pressure applications involving the sealing of low-viscosity oils and dry-cleaning or other solvents such as carbon tetrachloride, trichlorethylene, benzene, or methyl ethyl ketone. Aromatic hydrocarbons and chlorinated solvents (among others) have a very high swelling effect on most of the oil-resistant synthetic rubbers, so that this type of impregnated leather is able to perform satisfactorily in some solvents which synthetic rubbers cannot tolerate.

The least porous of the new leathers has been developed for hydraulic packings operating at pressures to at least 6000 psi. Maximum pressure has not yet been established. Test data shown in *Fig.* 4 indicate that packings of this material are far superior to the traditional type of wax-impregnated leather, not only for reducing the leakage obtained at normal room temperatures but particularly for improving performance at high temperatures.

Limited-Depth Impregnation: The newest development in the mechanical leather field is a limited-depth impregnation designed specifically for use in shaft type oil seal packings. As the name indicates, the impregnation is held to a specific depth, usually not more than 1/32-inch of the grain surface of the leather. With the impregnation restricted to a certain depth, there is minimum change in the physical characteristics of the leather. Flexibility of seals thus treated permits them to operate at higher speeds, lower torques, lower operating temperatures, and to follow greater shaft eccentricities than formerly possible.

Summary: Several general advantages are realized by these specially impregnated leathers. Cost of the new series of leathers is less than that of synthetic rubbers. Special designs not formerly possible using thinner, more flexible packings are now available. They generate less heat, with less power loss. This is particularly important where fractional horsepower motors are used.

In severe, high-speed applications, the impregnated leathers have permitted special designs which have brought about major reductions in operating temperature. Seals have been run for considerable periods at speeds in excess of 2000 fpm, and at substantially higher speeds for short intermittent periods. At the present time specially designed and treated leathers are solving sealing and packing problems involving extremely low temperatures.

The Tanners Council and the American Leather Chemists Association are working presently to increase the heat resistance of leather still further. It is definitely foreseeable that co-operative research within the leather industry and thorough design study will bring lower operating temperatures, greater heat resistance, and subsequently, longer life throughout the entire range of sealing and packing applications.

The answer to the problem of obtaining high density in limited space is the use of . . .

HEAVY METALS

By Don Wackerle *Metals and Ceramics Div.*
P. R. Mallory & Co. Inc., Indianapolis, Ind.

WHEN a material with a higher density than iron or steel is desired, a design engineer is faced with several problems. A common material such as lead is often unsatisfactory because of low strength characteristics. The difficulty in fabrication of tungsten, combined with its poor machinability, render it unsatisfactory for any use requiring a complicated size or shape and

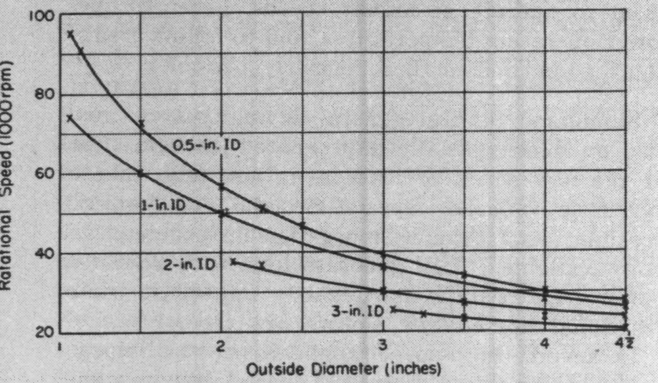


Fig. 1—Maximum permissible rotational speeds for hollow Mallory 1000 heavy metal cylinders (calculations based on 25,000 psi, no factor of safety)

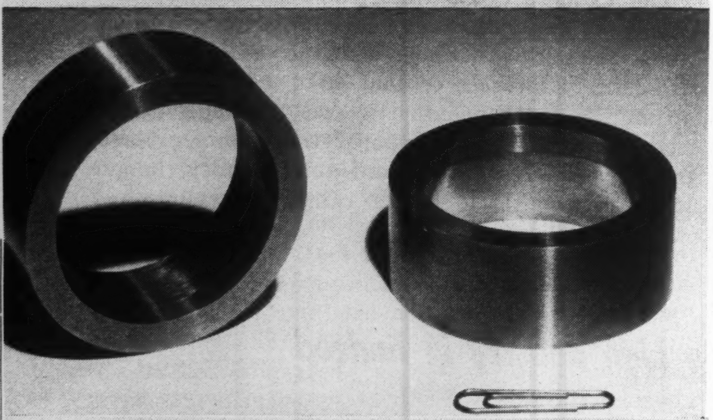


Fig. 2—Heavy-alloy gyroscope rotor with 0.00075-inch step machined on ID

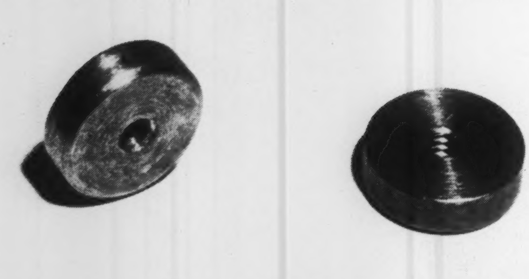


Fig. 3—Small balance weight, weighing less than 0.01-pound, has tapped center hole

needing close tolerances. Other high-density materials, such as gold, platinum and osmium, are too expensive for common usage.

Research to overcome these limitations has resulted in the development of several special alloys, among them a sintered tungsten alloy, Mallory 1000 Metal, composed of approximately 90 per cent tungsten, 6 per cent nickel, and 4 per cent copper. Density is approximately 16.9 grams per cubic centimeter; tensile strength is approximately 100,000 psi. Complete physical properties of a typical alloy are listed in TABLE 1.

Production Methods: Heavy metals are produced by modern powder metallurgy techniques. After mixing, the alloy powders are pressed in either automatic high-production presses or slower high-tonnage hydraulic presses, and the material is then sintered in electric furnaces. Shrinkage of the pressed parts during sintering is quite high.

In another method of manufacture, known as the "hot press" method, the pressing and sintering operations are combined. This type of fabrication is the newer of the two processes, and is not yet used extensively through the industry.

A third method of manufacturing, a development of P. R. Mallory & Co. Inc., is contour pressing, a technique which produces uniform-density parts in unusual and nonsymmetrical shapes. Contour pressing eliminates cracking and distortion which are sometimes problems in the production of powder metal parts of unusual shapes. Chief advantage is that fabrication of pieces with pressed contours in many cases eliminates, and in all cases reduces, machining operations.

Applications of Heavy Metals: Heavy metals are utilized in three broad fields of application: as

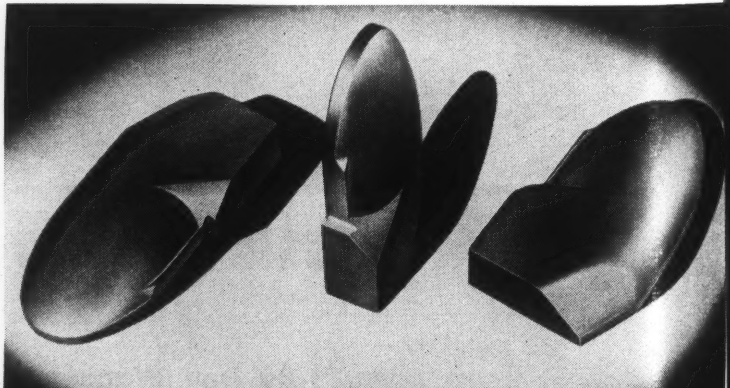


Fig. 4—Six-pound counterweights contour-pressed to close tolerances

rotating inertia members; as counterweights; and as effective radiation shields.

ROTATING INERTIA MEMBERS: High density, good strength, and machinability are characteristics of these alloys which make them "naturals" for gyroscope and similar applications. The moment of inertia of a rotor is a function of its density. Therefore, a heavy-alloy rotor has approximately twice the moment of inertia of a brass or steel rotor of the same size at the same rotational speed. A smaller heavy-alloy rotor may have the same or greater moment of inertia at the same or less rotational speed.

Because of the density advantage of heavy metal it is often possible to reduce the total size of the gyroscopic instrument by the use of a smaller rotor. This has not only the advantage of conserving valuable space in aircraft but often results in a total cost reduction in the unit itself. The decrease in size of other components and the consequent cost saving may often more than offset the additional cost of the heavier rotor. *Fig.* 1 shows the maximum recommended rotational speeds of hollow cylinders of Mallory 1000 Metal.

Typical rotor applications are navigational instruments in aircraft and ships, automatic pilots, bomb sights, and flow meters. *Fig.* 2 is an illustration of a rotor used in a gyroscope. Note the 0.00075-inch "step" which is evidence of the favorable machinability of the tungsten alloy. This type of machining is typical of large production runs of gyroscope parts.

COUNTERWEIGHTS: Heavy alloys are used in a variety of counterweight applications, ranging from small balance weights weighing less than 0.01-pound used in a guided missile, *Fig.* 3, to a counterweight weighing approximately 6 pounds used on an airborne radar antenna, *Fig.* 4.

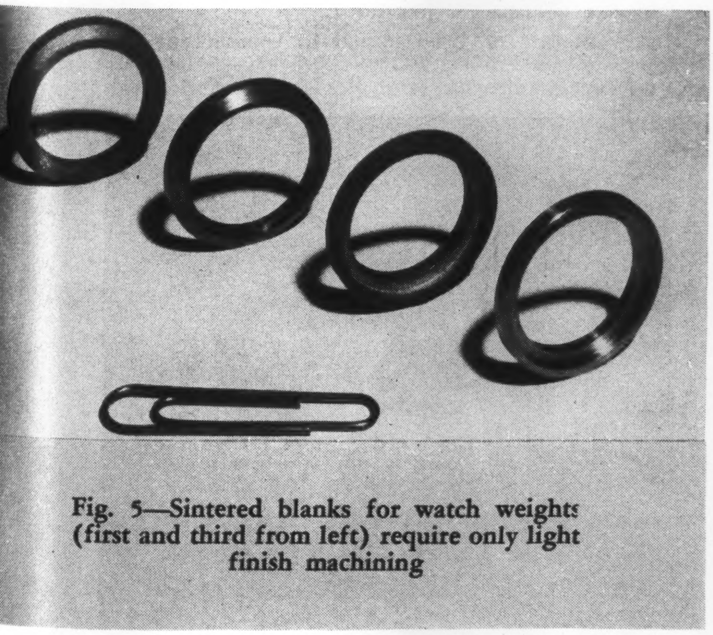


Fig. 5—Sintered blanks for watch weights (first and third from left) require only light finish machining

Heavy-alloy watch weights, *Fig.* 5, are used in self-winding watches. The sintered blank is machined and cut into segments which are then placed at the maximum radius of a freely pivoted member. Movement of the wearer's arm causes the weight to oscillate and, through gearing, to wind the mainspring. By use of a precision sintering technique these materials are made very close to the machined size and, consequently, material waste and machining time are low.

Another application allied to counterweights is the use of the tungsten alloy as a vibration damping member. A piece of the material is inserted in a hole at the end of a boring quill. This assembly tends to stop or reduce tool chatter and vibration. There is reason to believe that tool breakage is materially reduced, and tool life increased.

Heavy metal may be used advantageously as a weight to balance aircraft ailerons. New thin wings of fighter planes makes the use of thick brass or lead weights undesirable. Tachometers and accelerometers also use heavy metal. Here, the mass of the material works against mechanical, hydraulic, or air pressure in these recording instruments. Setscrews of heavy alloys are also finding increasing usage in counterbalancing where space is at a premium. Other applications as counterweights include fire control instruments, governors, crankshafts, and in helicoptor rotor blades.

RADIOACTIVE SHIELDING: As the use of radioactive material increases in industry the value of heavy metal for a radioactive shield is becoming more and more apparent. *Fig.* 6 shows the gamma radiation shielding ability of a typical tungsten alloy and other materials. In many cases, due to space, temperature or strength problems, common shielding materials such as lead are not satisfactory.

Recently, samples of heavy metal were placed

Table 1—Typical Properties of Mallory 1000 Metal

Hardness: Rockwell C	24–30
Brinell	250–285
Ultimate tensile strength, average (psi)	105,000
Yield strength, 0.2% offset, (psi)	75,000
Proportional elastic limit (psi)	25,000
Modulus of elasticity (million psi)	40
Elongation (% in 2 in.)	2.5
Modulus of rupture average (psi)	205,000
Deflection, 1½-in. gage, simple beam (in.)	1/16
Endurance limit, rotating beam (psi)	40,000
Electrical conductivity (% IACS)	14
Thermal coefficient of expansion, —68 to 900 C, (in./in./deg C)	0.0000071
Density Properties	
Parts weighing between 1 and 2500 gm	
Average (gm/cc)	16.96
Extreme low individual value (gm/cc)	16.71
Parts weighing between 2501 and 5000 gm	
Average (gm/cc)	16.87
Extreme low individual value (gm/cc)	16.50

in the atomic pile at Oak Ridge, Tenn., along with control samples of pure tungsten, nickel-tungsten, and copper-tungsten. After being subjected to a high neutron flux density for four weeks, preliminary measurements indicated two primary radiation products: tungsten-187 with a 24-hour half life, and tungsten-185 with a 74-day half life. Relative radiation intensity of the samples now, several months after removal from the pile, represents a tolerable time of more than 8 hours at working distances of 3 inches.

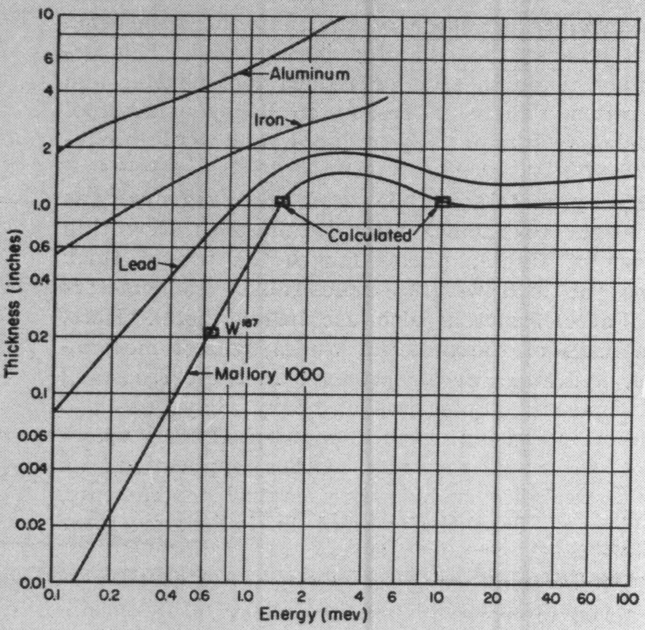


Fig. 6—Above—Gamma radiation absorption characteristics of aluminum, iron, lead, and Mallory 1000 (thickness to reduce gamma or X-radiation by factor of 10)

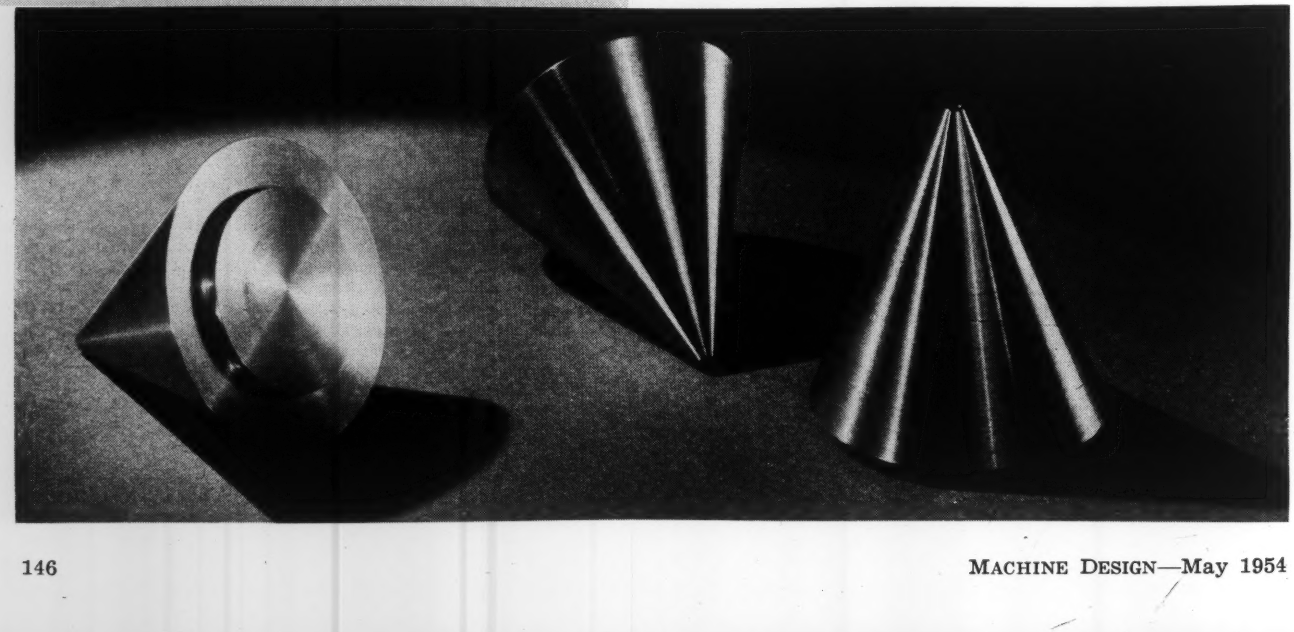


Fig. 7—Below—Heavy metal cones used for radiation shielding

High voltage X-ray absorption tests have proved the material to have much better absorption properties than lead when used as a shield for 100 mev X-rays from a Betatron.

Tungsten alloy cones used in a "penetron," an instrument used to measure wall thickness of pressure vessels and piping, are shown in *Fig.* 7. A cone containing radium and a "window" through which radiation is directionally released in the penetron is inserted into the object whose wall thickness is to be measured. The dense metal shields the Geiger counter in the instrument from gamma rays.

The heavy alloy is utilized in other radioactive situations such as teletherapy units for medical treatment of cancers and tumors by radiation and radiographic instruments for industrial uses. Its use has permitted the design of smaller, more flexible teletherapy units; these units are able to use a higher intensity of radiation and still have shielding that would not be possible with either lead or brass.

Excellent mechanical surface finishes on the tungsten alloy can be produced by turning, boring, drilling, milling, and shaping and grinding. No exact measures on energy requirements for machining have yet been made; but, in general, machining is similar to the machining of gray iron. Life of tools used in machining heavy metal is generally shorter than the life of tools used to machine materials such as free-machining brass; however, fine tapping is readily accomplished. The material is regularly machined by boring to tolerances of ±0.0003-inch in 1.5 inches.

Corrosion resistance exceeds that of 18-8 stainless steel in a media of 20 per cent hydrochloric acid at 95 F. Under this condition, the corrosion rate is 0.000042-grams per square centimeter per hour while that of stainless steel is 0.000099-grams per square centimeter per hour.

Heavy metals may be joined to themselves and to other materials by several methods. These include: (1) mechanical joining (preferred), (2) copper brazing, (3) silver soldering, (4) soft soldering, (5) shrink fitting, (6) press fitting, and (7) welding. In addition to these methods, special techniques, such as sinter brazing, are used to join one piece of heavy metal to another.

Cost and Availability: Price of heavy metal depends upon many factors such as quantity, shapes, tolerances, etc. However, in the "as-sintered" state, the approximate price is $15 to $20 per pound.

It is customary to design new pressing tools for large production orders, as this normally is the most economical method of operation. However, available tools will furnish a great selection of standard shapes such as bars, rods, and cylinders. "Rough-sintered" stock is often furnished for machining to desired prototypes.

How modern plastics are meeting severe design requirements is well demonstrated by fluorocarbons such as . . .

KEL-F PLASTIC

By J. A. Jupa

Chemical Mfg. Div.

The M. W. Kellogg Co., Jersey City, N. J.

CHEMICAL inertness to all known chemicals, a toughness and strength at temperatures from below zero to over 300 F, consistently high electrical insulating properties and dimensional stability are a few of the properties offered by trifluorochloroethylene polymer plastics. They have been responsible for the rapidly increasing use of this relatively new material in military and commercial applications of all types. Recorded applications, based on these and other properties, range from insulation for high-temperature hook-up wire and nitric acid filtering media, to oil-sight glasses and human eyeball replacements.

The Plastic: Kel-F, a trade-mark of the fluorocarbon plastic produced by The M. W. Kellogg Co., is a polymer of trifluorochloroethylene, a typical molecule consisting primarily of a carbon skeleton with fluorine and chlorine present in the ratio of three to one, respectively. This combination of carbon and halogens is characterized by a colorless, nonflammable thermoplastic with unique chemical, electrical and mechanical properties. It is differentiated from other plastics and fluorocarbons by the inclusion of chlorine in the molecule which contributes to the transparency, rigidity and

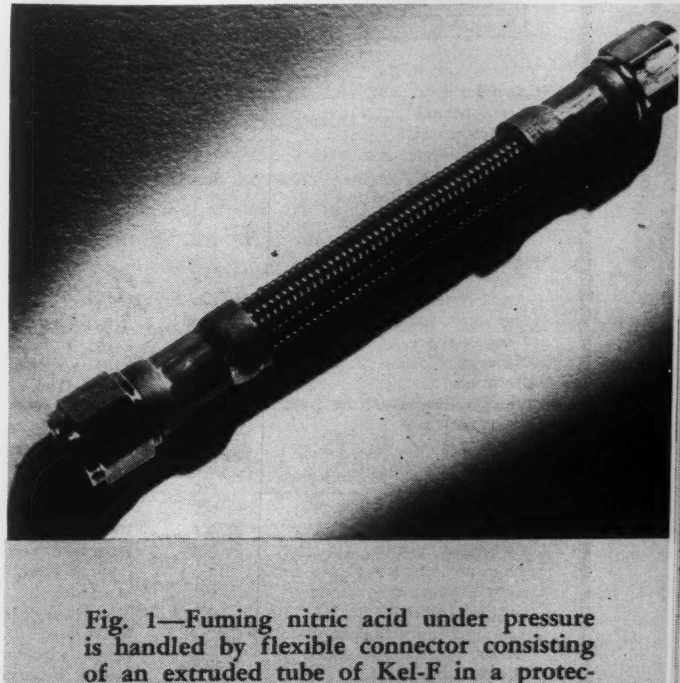


Fig. 1—Fuming nitric acid under pressure is handled by flexible connector consisting of an extruded tube of Kel-F in a protective sheath of stainless steel

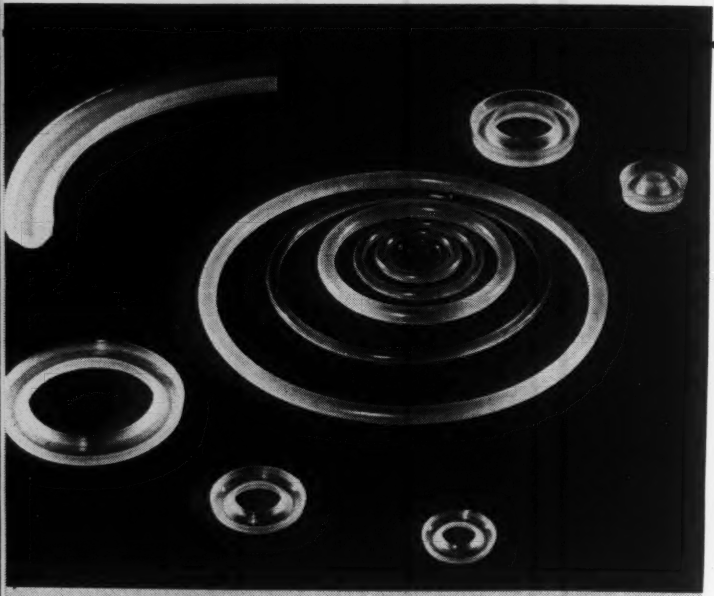


Fig. 2—Resistance to cold flow, abrasion and corrosion over a wide temperature range suits these molded and machined seals for severe service installations

flow characteristics of the polymer. Fluorine in the molecule is responsible for chemical inertness, dielectric properties and zero water absorption of the plastic.

Kel-F polymers are currently being produced in the following forms:

1. Unplasticized and plasticized (with Kel-F oils) molding powders.
2. High-polymer dispersions for dip or spray coatings.
3. Light to heavy oils; waxes; compounded greases.

Properties: Many applications of Kel-F depend on a single characteristic—either chemical, mechanical, optical or electrical—and just as many uses are based on the unique combination of properties.

CHEMICAL: An outstanding characteristic of Kel-F polymer is its resistance to attack by highly corrosive acids, alkalis, solvents and oxidizing agents. A few of the more than 135 chemicals to which this material has been found resistant, even after prolonged contact, are: fuming nitric acids, aqua regia, hydrogen fluoride and peroxide and sulfuric acids, TABLE 1. When used in contact with aromatic or highly halogenated solvents, slight swelling may take place which does not necessarily preclude its use with these materials. An application requiring chemical inertness, for example, is the armored fuel line, *Fig.* 1, consisting of an extruded 1-inch ID tube of Kel-F, which carries fuming nitric acid under pressure to jet and rocket engines. Drum liners and process pipeline liners of polymer film are additional examples of successful corrosion control.

MECHANICAL: The trifluorochloroethylene polymer plastics have excellent mechanical properties which are retained within satisfactory limits over a wide temperature range, TABLES 2 and 3. A high

Table 1—Chemical Resistance of Unplasticized Kel-F Polymer

(Per cent weight change—absorption—after 7 days at 25 C)

Chemical	Change
Acetic acid	0.0
Acetic anhydride	0.0
Acetone	0.1
Acetophenone	0.0
Acetyl chloride	0.1
Allyl chloride	0.2
Ammonia, anhydrous	0.0
Ammonium hydroxide 10%	0.0
Amyl acid phosphate	0.0
Aniline	0.0
Antimony pentachloride	0.0
Aqua regia	0.0
Aroclor 1254	0.0
Benzene	0.2
Benzonitrile	0.0
Benzoyl chloride	0.0
Bromine	0.0
Bromobenzene	0.0
Butyl acetate	0.3
n-Butyl ether	0.0
Calcium chloride (sat)	0.0
Carbitol acetate	0.0
Carbon disulfide	0.1
Carbon tetrachloride	0.4
Cellosolve acetate	0.0
Chlorine anhydrous (147 hr)	12.3
2-Chloropropane	0.3
p-Chlorotoluene	0.0
Chlorotrifluoroethylene (8 to 25 C)	0.1
Cresol	0.0
Cyclohexanone	0.0
Dibutyl phthalate	0.0
1,2-Dichlorobutane	0.0
3-Dichloroethyl ether	0.0
1,2-Dichlorohexafluorocyclobutane	0.1
Dichloropropylene	0.0
3,4-Dichlorotoluene	0.0
Dicyclopentadiene	0.0
Diethylamine	1.9
Diethyl carbitol	0.14
Diethyl cellosolve	0.8
Diethylenetriamine	0.0
Dioxane	0.0
Ethanol 95%	0.0
Ethyl acetate	1.2
Ethyl ether	3.8
Ethyl formate	0.2
Ethylene chloride	0.0
Freon 113	1.2
Formic acid	0.0
Furan	2.4
Halowax 1000	0.0
n-Heptane	0.0
Hydrochloric acid 10%	0.0
Hydrofluoric acid (anhy.)	0.0
Hydrofluoric acid 50%	0.0
Hydrogen peroxide 30%	0.0
Isopropyl ether	0.2
Methanol	0.0
Methyl acetate	1.0
Methylal	1.3
Methallyl chloride	0.1
Methyl n-butyrate	0.8
Methylene chloride	0.2
Methyl ethyl ketone	0.2
Methyl formate	0.1
Mineral oil	0.0
Naphtha solvent	0.0
Nitric acid fuming 89-95%	0.0
Nitric acid 10%	0.0
Nitrobenzene	0.0
Nitromethane	0.0
Oleic acid	0.0
Pentachloroethane	0.0
Perfluorotriethylamine	0.0
Piperdine	0.0
Propylene chloride	0.0
n-Propyl ether	0.3
n-Propyl formate	0.1
n-Propyl propionate	0.4
Pyridine	0.0
Santicizer B-16	0.0
Santicizer 8	0.0
Santolube 31	0.0
Sodium carbonate 2%	0.0
Sodium chloride 10%	0.0
Sodium hydroxide 10%	0.0
Stannic chloride	0.0
Sulfuric acid	0.0
Sulfuric acid 30%	0.0
Sulfuric acid 20% free SO_3	0.0
sym-Tetrachloroethane	0.0
Tetrachloroethylene	0.8
Toluene	0.4
1,1.2-Trichloroethane	0.0
Trichloroethylene	2.3
Trichloropropane	0.0
m-Xylene	0.4

(for a plastic) compressive strength of 30,000 psi is indicative of the plastic's low "cold flow" properties. On this property are based many critical gasket, seal and barrier applications where corrosion or temperature is a problem, *Fig.* 2. Performance of the material in such applications is further upgraded by its nonadhesive properties which prevent "freezing" to housings or channels, permitting easy maintenance and reuse of the fluorocarbon plastic. Kel-F has also been adapted to applications requiring special lamination or blending with fillers to obtain desirable operating characteristics.

The compressive strength of 30,000 psi may be increased to approximately 80,000 psi, when desired, by heat treatment. Advantage of high compressive strength and excellent plastic "memory" in valve and seal applications is evident in the fact that bearing loads of 8000 psi, for example, result in only a 4 to 5 per cent permanent set. High compressive and impact strengths qualify it for use as structural members, *Fig.* 3, with maintenance of excellent mechanical properties over a range of approximately 700 F—from −320 F to 390 F. Specific forms of this fluorocarbon plastic have been used at temperatures approaching absolute zero (−460 F) under certain conditions. A natural outgrowth of excellent low-temperature strength and resiliency has been its use in refrigerant gas valve seats and inserts. Compounded with glass fiber, these parts have demonstrated exceptional strength and abrasion resistance necessary for efficient service under severe conditions.

Table 2—General Properties of Unplasticized Kel-F

Specific gravity	2.1
Apparent bulk factor (cu in./lb)	28.8-91.0
Refractive index	1.43
Tensile strength (psi)	
77 F	4600-5700
248 F	460-570
Oriented film and fiber	30,000-50,000
Yield strength (psi)	
0.2% offset, 77 F	3640
Elongation (%)	28-36
Modulus of elasticity (psi)	
Tensile, 77 F	$192\text{-}226 \times 10^3$
Flexural, 77 F	182×10^3
Compressive, 77 F	$177\text{-}191 \times 10^3$
Compressive strength, 77 F (psi)	32,000-80,000
Flexural strength (psi)	
77 F	8200
158 F	1500
Stiffness (psi)	
—297 F	810,000
—148 F	500,000
32	250,000
212 F	22,000
392 F	4500
Impact strength, Izod notched, 77 F (ft-lb/in.)	3.62
Outdoor aging, one year	No change
Hardness	
Rockwell R	111-115
Durometer D	80
Abrasion resistance (loss, gm/1000 cycles)	
59.9946 gm, heat treated	0.0048
57.3753 gm, quenched	0.0175
Thermal conductivity	
($cal/cm^2/sec/deg\ C/cm$)	1.44×10^{-4}
($Btu/ft^2/hr/deg\ F/in.$)	0.418
Specific heat (cal/gm/deg C)	0.216
Thermal coefficient of linear expansion (in./in./deg C)	
—80 to 20 C	4.5×10^{-5}
20 to 150 C	7×10^{-5}
Resistance to heat, continuous (F)	390
Water absorption (%)	0.00
Burning rate	nil
Effect on metal inserts	Inert
Machinability	Excellent
Clarity	Transparent to translucent
Color	Unlimited

ELECTRICAL: Mechanical properties, combined with dielectric strength over extended periods through thermal cycling and high humidity have qualified Kel-F for many critical electrical and electronic applications. Aircraft hook-up wire, hermetic seal terminals (*Fig.* 4), exposed and confined insulation for communications equipment are a few examples for such applications. Particular importance is placed on the zero water absorption and nonwetting characteristics of the polymer which minimize power-robbing corona formation and surface flashover in sea level or at high-altitude operation. In molded form, Kel-F polymer insulation has electrical properties superior to most available plastics, with dielectric constant and dissipation factor in the RF, VHF and UHF ranges, comparing favorably with the best materials available, *Fig.* 5. Additional qualities of an arc resistance longer than 360 seconds, noncarbonization, as well as nonflammability, are contributing to longer life of electric devices, *Fig.* 6.

Kel-F has zero water absorption and remains dimensionally stable exposed to or immersed in water. These properties have become increasingly valuable to devices which need "environment proofing" to prevent electrical failure due to fungus formation in humid installations. The growing trend toward miniaturization of electronic components also takes advantage of these properties in critical parts such as miniature coil forms which are free from cracking of flashover tendencies. These properties are inherent to the material and not due to any special processing.

Extensive use is being made of this fluorocarbon

Table 3—Physical Properties of Film

	Unplasticized	Plasticized
Tensile strength (psi)		
Machine direction	6600	4600
Transverse direction	6300	3600
Elongation (%)		
Machine direction	100	200
Transverse direction	90	180
Tear strength (gm/0.001-in.)		
Machine direction	350	300
Transverse direction	200	200

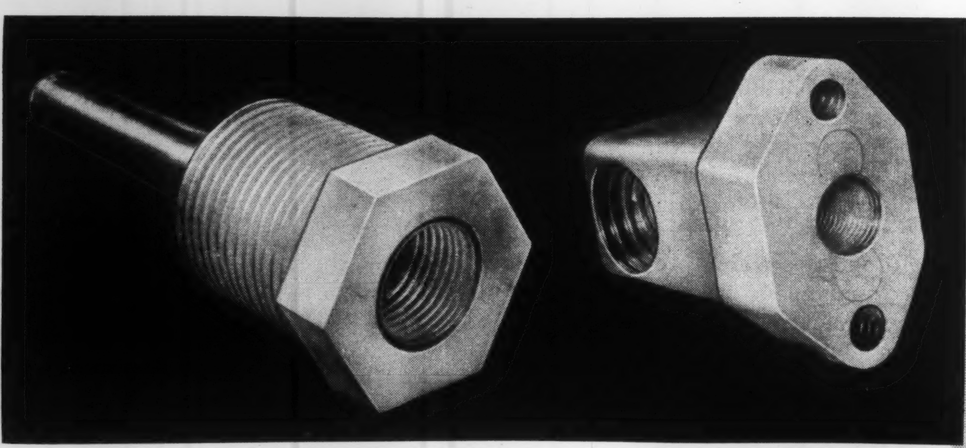


Fig. 3—Left—Gas sampling fittings for industrial analyzer afford leak-tight fits with all pipeline materials

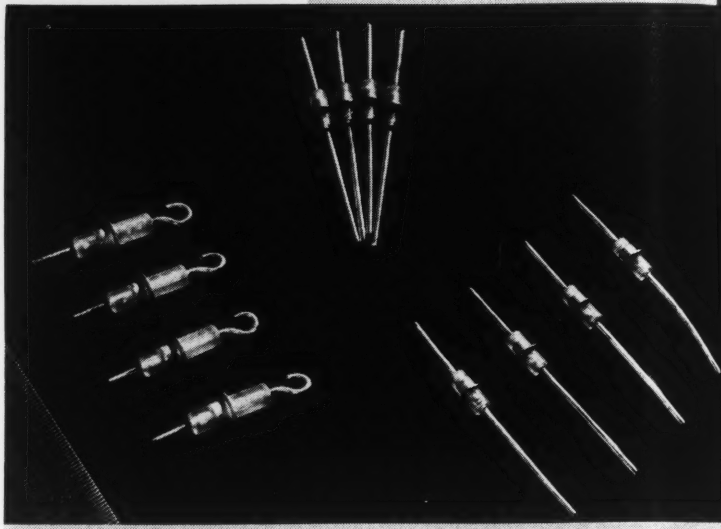


Fig. 4—Below—Dimensional stability of molded insulation under thermal cycling, high humidity and vibration prevents break in hermetic seal of terminal

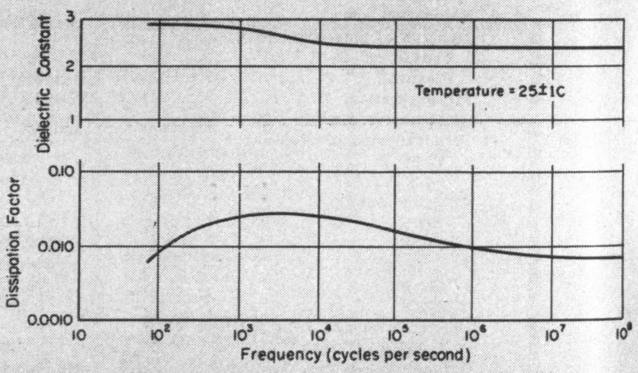


Fig. 5—Dielectric properties curves

in the form of film tapes and dielectric barriers. Continuous tests for water vapor transmission through extruded film of 3 mils or more show a zero water vapor transmission, using the General Foods Tests conducted at 100 F and 95 per cent relative humidity.

An advantage of Kel-F for these applications rests with its freedom from plasticizers which ordinarily are released in confined, "hot" installations to damage delicate metal parts and degrade insulation strength.

Producibility: Choice of Kel-F brings with it a certain latitude in the methods of producing parts. The basic molding resins are handled by conventional equipment—injection, extrusion, compression and transfer—capable of operating at temperatures between 450 F and 650 F. Primary consideration, in addition to proper, efficient mold design, is the precise control of temperatures in all parts of equipment coming in contact with the resin. Temperature control must be accurate to permit efficient molding while preventing thermal degradation of the polymer which would adversely affect its properties. The problem of thermal degradation, however, is minimized for the molder and fabricator who can detect and ascertain the degree of thermal degradation using the "NST" test (no strength temperature). This test can be used also as a quality check on molded and fabricated parts.

Although colorless, Kel-F may be blended with pigments and fillers to obtain unlimited color possibilities. Recently developed Kel-F polymer inks permit imprinting the molded plastic. Freedom of the virgin material from plasticizers allows metallic and nonmetallic inserts to be incorporated during molding without the danger of mechanical failure or chemical degradation of the resin or insert.

MACHINING AND FABRICATION: When the design of a part dictates production of finished parts by other than molding methods, a substantial variety of stock materials is available. The resin is currently being molded into finished products and supplied in the form of stock materials in the form of:

1. Molded sheet stock—$\frac{1}{64}$ to ½-inch thick to 60-inch diameter. Transparent in thicknesses up to ¼-inch on request.
2. Extruded rod—to 1-inch diameter in specified lengths.
3. Molded rod—to 4-inch diameter in lengths up to 24 inches.
4. Extruded tubing—up to 2-inch diameter in specified lengths and wall thicknesses.
5. Extruded strip—0.010 to 0.125-inch thick, 2 to 4-inch widths in specified lengths.
6. Film—0.002 to 0.010-inch thick lay-flat tubing in total widths up to 40 inches when split.

7. Extruded wire coatings, monofilaments, specialty compositions and colors according to specification.

Kel-F can be readily machined to close tolerances using standard or automatic equipment (Swiss screw). It may also be drilled, punched, sanded, buffed or polished with conventional equipment. Since it is a thermoplastic, the primary consideration is that excessive temperature be avoided during these operations.

Fabrication of products from extruded film entails the use of existing heat and RF sealing methods and equipment. Size of finished product (bags, liners, covers) is unlimited, with leakproof seams or joints being obtained at regular production rates. Products consisting of heavy sections of plastic, such as pumps, filter assemblies and feed systems made of sheet and plate, will be possible in the future, using "hot-gas-welding" techniques now being tested.

Special Processing: Although applications thus far are few and highly specialized, Kel-F polymer properties may be modified somewhat by heat treatment. The relatively soft, resilient amorphous form of plastic may be heat treated between 350 F and 380 F to crystallize the plastic and render it considerably harder and less yielding—a phenomenon unique among thermoplastics. Stability of the fluorocarbon is not affected by this treatment and makes it possible to control the physical qualities of molded parts made from the same basic resin.

Heat treatment has been found valuable in cases where certain injection-molded parts have undergone considerable strain in the molding process. Such stressed parts may be stress relieved by annealing them, thereby improving their dimensional stability at elevated temperatures. Stress relieving is usually carried out at temperature of approximately 257 F for a period of from 24 to 48 hours. If higher service temperatures are encountered, the parts are annealed at temperatures slightly above the intended service temperatures.

Coating with Polymer: Dispersions of high-polymer resin in volatile organic compounds are being employed for dip or spray coating of metal surfaces. Smooth, nonporous and nonpeelable coatings are obtained which are corrosion resistant, nonadhesive (self-cleaning), thermally stable and damage resistant. The dispersions are applied to properly cleaned surfaces by a "coat-dry-bake" system, until the required thickness is obtained. Each application of polymer is allowed to dry and is then baked in an oven at temperatures between 480 F and 500 F. The resultant coating has exceptional adhesion to the base material and has essentially the same properties as Kel-F in molded form, *Fig.* 7.

Future Aspects: Improvements in the molding and fabrication of Kel-F and its application to specific fields of service are continually being made. Advances in die design promise more rapid and economical production of parts. In the protective coatings and linings field, tests on the use of bondable-to-metal laminates of Kel-F and glass fiber point to the solution of the problem of satisfactorily cementing or bonding the nonadhesive virgin material to other material, using glass fiber as the cementable medium. Improvements in the application of baked-on coatings of polymer in corrosion control are leading to the successful coating or lining of permanently installed large or complex

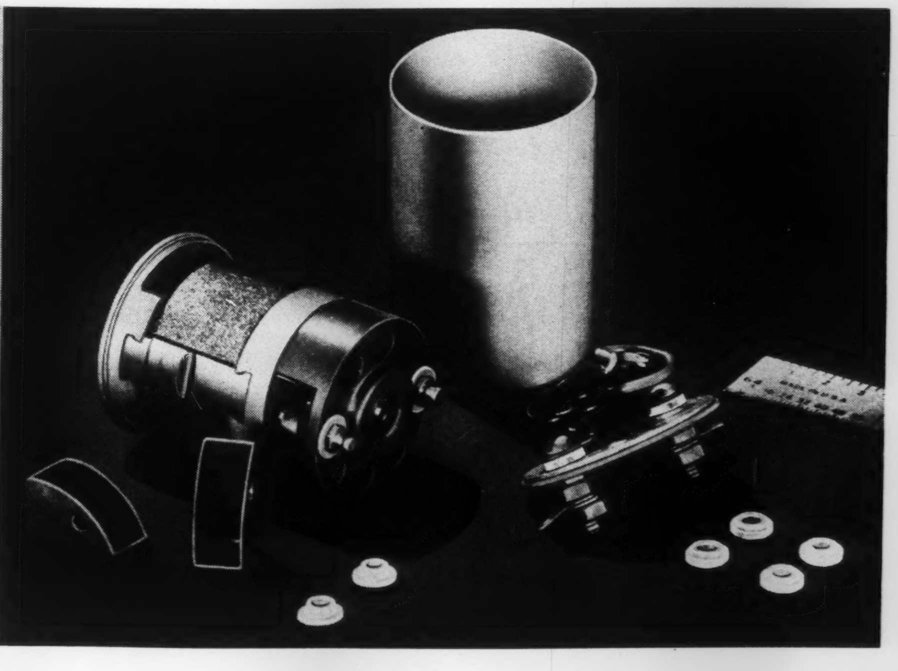


Fig. 6—Dielectric properties at elevated temperatures, nonflammability and low thermal expansion of servomotor brush and terminal insulators permitted reduction in unit size and increased efficiency

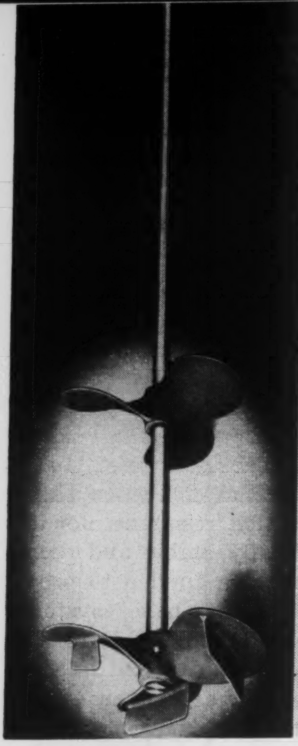


Fig. 7—Baked-on nonpermeable coating allows agitator to be used with abrasive and corrosive materials. Nonadhesive qualities make part virtually self-cleaning

vessels. Considerable economies will result in the fabrication of large or composite products of Kel-F through the use of the "hot-gas-welding" method, removing the restrictions imposed by the capacity of existing methods of production and opening the field of rigid-container applications.

Other factors will play a part in the application of the trifluorochloroethylene polymers in the foreseeable future. The availability of printing inks of Kel-F, now finding success in the color coding or spiral striping of electrical wire insulation, will answer the need of other branches of the electrical and electronics industries in the coding or identification of complex circuits and components. Results of preliminary studies on the properties and applications of Kel-F polymer oils, greases and waxes in high-temperature and corrosion-resistant lubricants, may well broaden to include the chemical, medical and electronic fields. Uses are indicated in the form of inert hydraulic oils, sterilizing bath fluids and "potting" and sealing fluids.

The completion and pending full-scale operation of a new facility for the production of an additional 1 million pounds per year of trifluorochloroethylene polymer will exert a strong influence in opening new fields of application. Although the price of Kel-F has been reduced three times in its history to the present level of $11 to $18 per pound, expanded production would undoubtedly permit downward adjustment of the price to attract areas where its use has been prohibited solely because of its cost.

Automatic temperature correction of magnetic and electrical properties in instrumentation devices is provided by . . .

TEMPERATURE-COMPENSATOR ALLOYS

By Warren S. Eberly *Metallurgical Dept.*
The Carpenter Steel Co., Reading, Pa.

MANY types of equipment today—and the instrumentation they employ—must operate over a wide range of ambient temperatures such as −70 F to 250 F. Temperature variations of this order present a serious problem to machines of all sorts and particularly so to instruments which usually contain permanent magnets and other elements sensitive to temperature changes. Thus if these variations in the behavior of materials are not somehow compensated, the accuracy of the results will be greatly impaired, since the percentage registration or the efficiency of the instrument will vary as a function of the ambient temperature. The only correct reading then would be the value shown when operating at the same temperature at which the instrument was adjusted, usually about 80 F.

Thus it is a definite essential that many instruments be compensated by some means to correct for temperature variations. One of the simplest and surest means of accomplishing temperature compensation is by the use of a magnetic shunt composed of a thermomagnetic alloy, known commercially as Temperature Compensator Alloy.

The watt-hour meter, an instrument designed for measuring electric current consumption, is a typical example of an instrument requiring temperature compensation when placed out of doors, *Fig.* 1. Here the changes in atmospheric temperature affect the properties of three components: the permanent magnet, the drag disk, and the resistance of the potential circuit. Outdoor watt-hour meters may experience temperature as low as −40 F when exposed to winter winds as well as temperature of 180 F under the rays of the summer sun. This high temperature is easily possible under the protective glass casing. As the outdoor temperature increases above 80 F, a watt-hour meter without temperature compensation is likely to record a higher consumption than actually used. With decreasing temperatures below 80 F, the recording would be below the actual consumption. Per cent registration without temperature compensation can vary as much as 93 to 107 per cent over the range of −40 F to 180 F.

Tachometers and automobile speedometers likewise require temperature compensation for accurate reading. These instruments contain a permanent magnet and an aluminum drag disk. When subjected to subzero atmospheric temperatures the percentage registration is low, and when subjected to temperatures in excess of the calibrating value, the registration is high. The difference can be as much as 18 mph at an actual 60 mph through the temperature range of 0 F to 110 F.

Voltage regulators for automotive and aircraft use are subjected to temperatures ranging from −40 F to 200 F, the variation resulting both from ambient temperature and heat resulting from a resistance coil used for control purposes. By employing a bar of the temperature-compensator alloy in the magnetic path circuit, the performance of the regulator can be accurately controlled.

How Temperature Affects Performance: Changes in atmospheric temperature affect the performance of these instruments for two principal reasons: first, because the pole strength of the permanent magnet decreases nearly linearly with temperature increases from −40 F to 180 F, and second, because the electrical resistivity of alloys increases with increasing temperature. The effect of temperature on resistivity is felt both in the aluminum or bronze drag cup or disk, and in the magnetic windings.

Table 1—Nickel Content vs. Curie Temperature in Iron-Nickel Alloys

Nickel (%)	Temperature (F)	Nickel (%)	Temperature (F)
28.50	112	31.0	320
29.15	162	32.5	390
30.0	240	33.5	460

Since many of the instruments contain several components that are affected by ambient temperature, the variation in performance is cumulative. Temperature compensation for all parts can be achieved by placing the temperature-compensator alloy in a magnetic path circuit. The degree of compensation will be a function of the magnetic properties of the alloy and the manner of positioning the alloy shunt in the magnetic path circuit.

Types of Alloys: Most commonly employed temperature-compensator alloys are of the iron-nickel type in which the nickel content varies from 28.5 to 33.0 per cent. Alloys with this nickel content show temperature - sensitive magnetic properties that can be used to advantage. Magnetic permeability decreases nearly linearly from subzero temperatures up to their Curie temperature—the temperature below which it is magnetic and above which it is nonmagnetic. TABLE 1 lists the approximate Curie temperature for given nickel contents.

The iron-nickel alloys containing less than 28.5 per cent nickel are not applicable, since a large temperature difference exists between the critical or transformation point on heating and cooling. After cooling from an elevated temperature to render the alloy completely austenitic, temperature-sensitive magnetic properties will be shown above normal temperatures. However when cooled to subzero temperatures, transformation occurs. Accompanying this transformation are changes of magnetic

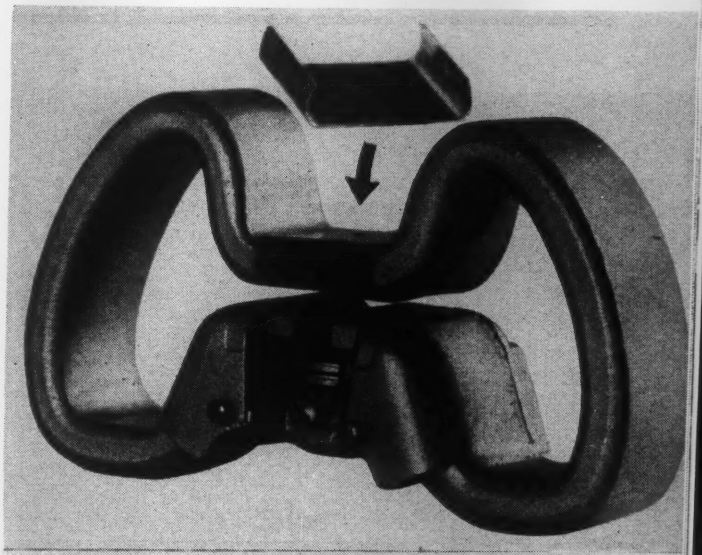


Fig. 1—Permanent-magnet assembly for watt-hour meter employing a magnetic shunt of iron-nickel temperature-compensator alloy

properties and Curie temperature, thus rendering the alloy useless. Alloys of this type are classified as "irreversible." With nickel contents above 28.5 per cent, transformation of the crystalline structures does not occur at subzero temperatures; therefore, the temperature-sensitive characteristics are "reversible" through cycles below and above the Curie temperature. Alloys containing more than 33.0 per cent nickel offer no advantageous properties as the change in magnetic permeability per degree of temperature is very slight. There have been no temperature compensation applications for alloys containing more than 33.0 per cent nickel.

Fig. 2 illustrates the effect of nickel on the temperature-permeability characteristics of fully annealed samples. Magnetic tests were conducted at a magnetizing force of 46 oersteds (93 ampere turns per inch). This magnetic field strength has been selected for quality-control purposes because at this value iron-nickel alloys with 28.5 to 33.0 per cent nickel approach magnetic saturation—the maximum flux carrying capacity of the alloys. When subjected to higher magnetic field strengths, such as shown across the poles of a permanent magnet, the same magnetic characteristics will be exhibited. At times it is necessary to employ the alloy in magnetic fields less than 46 oersteds. *Fig.* 3 shows the temperature-permeability properties of annealed 29.5 per cent nickel alloy at various magnetic field strengths.

Table 2—Selection of Compensator Shunt

	Shunt *A*: 32.5% Ni, ½ x 0.020-in., 0.065-cm²			Shunt *B*: 29.5% Ni, ½ x 0.060-in., 0.192-cm²			Shunt *C*: 29.5% Ni, ½ x 0.040-in., 0.130-cm²	
Temp. (F)	*U* at *H*=46	Lines Carried*	Δ Lines from 80 F	*U* at *H*=46	Lines Carried	Δ Lines from 80 F	Lines Carried	Δ Lines from 80 F
0	202	605	80	105	930	515	630	348
20	195	585	60	93	821	406	558	276
40	190	570	45	78	670	275	466	184
60	184	550	25	61	540	125	365	83
80	176	525	0	47	415	0	282	0
100	168	502	—23	28	247	—168	168	—124
120				17	150	—265	102	—180

* Lines carried = 46 *U* × area of shunt.

In practically all applications, the temperature-compensator alloy is used as a shunt to by-pass magnetic lines of force or as a leg in a magnetic path circuit. *Fig.* 4 illustrates the compensator alloy employed as a shunt across the poles of a permanent bar magnet in a tachometer. For a range of ambient temperatures, the registration of this tachometer will depend upon the magnetic lines of force by-passed by the compensator shunt between the poles. The flux-carrying capacity of the shunt has to correct for the change in pole strength and the change in electrical resistivity of the aluminum drag cup. The remainder of the magnetic lines of force pass through the aluminum drag cup and produce eddy currents. This results in a dragging action of the cup to follow the rotation of the permanent magnet. The degree of compensation will be a function of the permeability properties of the shunt, cross-sectional area of the shunt, and length of shunt.

Temperature compensation can be achieved in a reactance circuit by encircling a portion of the closed electric circuit with a disk or plate of compensator alloy. The entire assembly must then be placed in the alternating magnetic field that requires compensation.

Fig. 2—Influence of nickel content on the permeability-temperature characteristics of temperature-compensator alloys

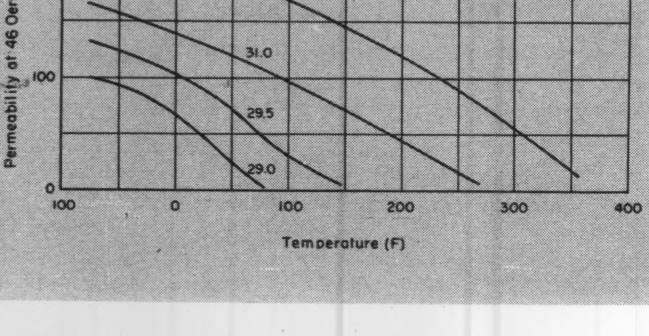
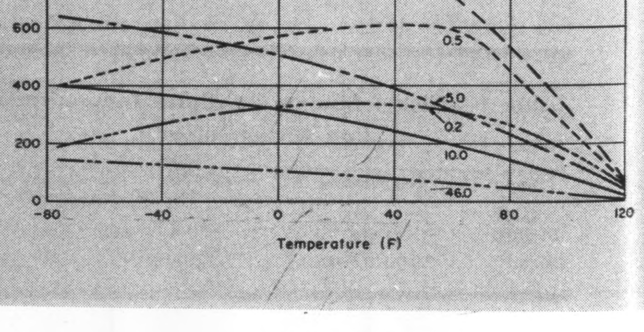


Fig. 3—Effect of magnetic field strength upon temperature-permeability characteristics of 29.5 per cent nickel temperature-compensator alloy



Designing for, Temperature Compensation: As changes in ambient temperature may have an effect on several component parts, temperature compensation is one of the last items to be considered in the design of a new instrument. The relationship of per cent registration versus temperature should first be determined without the aid of compensation. Tests may then be repeated having a shunt, of known magnetic properties and dimensions, placed in the magnetic path circuit. Effects of a compensator alloy and dimensions of the shunt for compensating a typical instrument are shown in *Fig.* 5.

In *Fig.* 5, the heavy-line rectangle is the required performance rating that must be maintained over the temperature of 0 F to 120 F, required per cent registration being 99 to 101 per cent of the true input. TABLE 2 shows the magnetic properties, the cross-sectional area and the magnetic flux-carrying capacity of the shunts tested.

In *Fig.* 5 all registration curves converge on 100 per cent at 80 F since this temperature was employed to adjust the instrument for 100 per cent registration. The heavy solid line indicates registration of the instrument without the aid of a compensator alloy.

When testing shunt *A* (32.5 per cent nickel alloy having a cross-sectional area of ½-inch by 0.020-inch) a slight degree of compensation results, decreasing the error. The compensation is insufficient to have the instrument meet the requirements.

Next shunt *B* (29.5 per cent nickel having a cross-sectional area of ½-inch by 0.060-inch) overcompensates the instrument at all temperatures above and below 80 F. Flux-carrying capacity of shunt *B* is much greater than that of shunt *A*. Note the rate or greater flux carrying capacity per degree F as shown by the Δ-line column in TABLE 2. This column illustrates the difference in flux-carrying capacity between the test temperature and the calibrated temperature.

Reducing the thickness of shunt *B* from 0.060 to 0.040-inch decreases the compensation as shown by shunt *C*. Compensation of shunt *C* meets the requirements of being within 99.0 to 101.0 per cent of the input over the range of 0 F to 120 F. This is a typical example of how tests can be conducted to determine the proper temperature-compensator alloy, design of shunt, and position of shunt when used with a permanent magnet.

It is customary to conduct periodic quality tests on instruments taken from the assembly line. Slight adjustments can be made in the flux-carrying capacity of the compensator alloy by blanking different sized holes or notches in the shunt, changing cross-sectional area of the shunt, or varying the air gap between the shunt and the permanent magnet.

In some instances proper temperature compensation cannot be achieved by a single shunt, and a compound shunt must be employed. The compound shunt consists of two different grades of compensator alloy placed side by side.

The temperature-compensator shunt is generally held in position by a clamp or the alloy itself is formed in the shape of a clip. Welding or brazing the shunt is not recommended since the elevated temperatures will cause a difference in magnetic properties between shunts produced from the same piece of strip or bar. Positioning of the permanent magnet and shunt within an aluminum or zinc

Fig. 4—Diagram of tachometer showing use of a temperature-compensator shunt

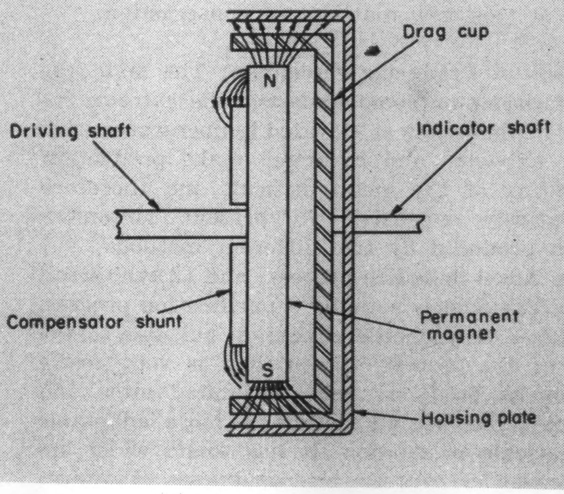
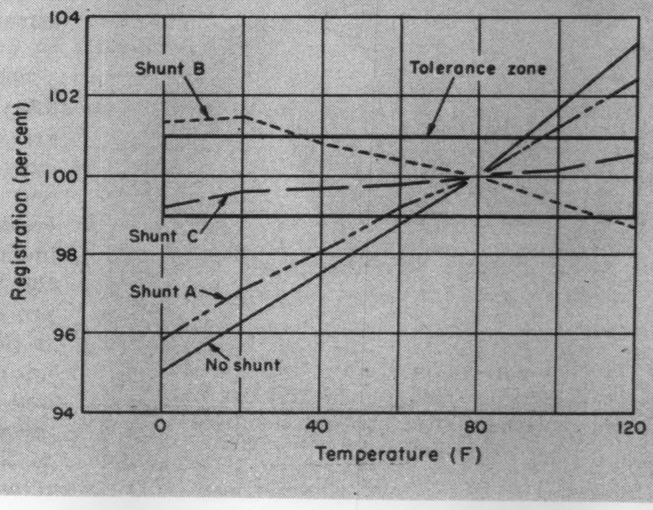


Fig. 5—Test curves of registration versus temperature developed in the matching of a shunt to a particular application. Objective of confining the error of the "no-shunt" curve to the rectangular tolerance zone is met with shunt C



die casting has not presented any problems; the time at heat is very short and no alloying of the shunt takes place.

In addition to the applications mentioned, temperature-compensator alloys have been applied to other devices such as laminations in a temperature-sensitive transformer, thermal switches, and sensitive relays.

Temperature-compensator alloys offer many desirable properties that can be utilized for control purposes. Their possibilities in this field have by no means been exhausted and, in the light of past experience, seem to be limited only by the degree of ingenuity employed in their application.

Excellent corrosion resistance where other metals fail is one of the major advantages of . . .

ZIRCONIUM

By John D. Roach *Senior Metallurgist*

Zirconium Metals Corp. of America Niagara Falls, N. Y.

ZIRCONIUM metal of commercial purity is considered a comparatively recent addition to the many useful engineering products of the metal industry although it has been in production, on a rather limited scale, for a number of years. Many consider zirconium as the sister metal of titanium although some of the chemical and metallurgical characteristics of the metals themselves are quite different. The primary attraction of titanium is its high strength with respect to its relatively low density. On the other hand, the density of zirconium is much closer to that of steel, and it is the excellent corrosion resistance of this metal which results in its greatest engineering applicability in corrosive media where most other metals, including titanium, are not suitable.

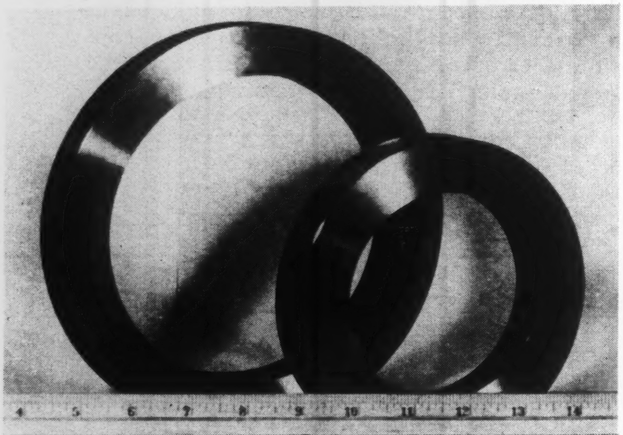


Fig. 1—Zirconium scatter rings, used to determine scatter characteristics of the material under neutron bombardment

The potentialities of the metal must be evaluated before it can be useful. This article will review briefly the information available on zirconium to familiarize engineers and designers with various aspects of this new material of construction.

Methods of Producing Zirconium: The high stability of zirconium compounds and the extreme reactivity of the metal at elevated temperatures with oxygen, nitrogen, and hydrogen make production and melting of the metal difficult and therefore comparatively expensive. At present, zirconium metal is produced by two different methods: (1) the Van Arkel or iodide process; and (2) the Kroll process. The first is actually a purification process. It produces very ductile zirconium but, due to the nature of the process, the product is very costly and can be produced only in limited sizes and quantities. The second method is more adaptable to large-scale production. It has found wider application as a process for producing zirconium metal and is the one now being used by the Zirconium Metals Corp. Several other methods, including electrolytic reduction of zirconium compounds, are now being studied by various investigators but to date none have reached the commercial stage.

With the Kroll process, the metal is produced in the form of a gray crystalline sponge, which is then consolidated by melting. The high affinity of zirconium for atmospheric gases and the harmful effect of these gases on the properties of the metal makes a carefully controlled atmosphere essential for melting operations. Techniques employed in the processing of the zirconium ingots produced are similar to those used with other metals. The ingots are forged or hot rolled at approximately 1400 F, at which temperature scaling and oxygen absorption is insufficient to affect the quality of the product. Cold rolling results in an increase in strength and hardness and a rapid decrease in ductility so that intermediate annealing treatments at approximately 1300 F are necessary to restore the required ductility. These techniques have been perfected to the point where commercially pure zirconium metal is now available in the form of sheet, strip, plate, wire, bar, rod, and forgings.

Commercial zirconium metal usually contains approximately 1.5 to 2.2 per cent hafnium, depending on the source of the ore from which the metal was obtained. It is this hafnium content which distinguishes commercial zirconium from the high-purity or low-hafnium grade used by the Atomic Energy Commission because of its nuclear properties, *Fig.* 1. The published properties of commercial zirconium metal are, therefore, actually those of a zirconium-hafnium alloy. A typical analysis of commericial zirconium metal is 0.15 per cent carbon, 0.10 nitrogen, 0.07 oxygen, 0.75 iron, 0.04 chromium and 1.9 hafnium.

Table 1—Physical Properties of Zirconium Metal

Atomic number	40
Atomic weight	91.22
Density at 20 C (gm/cc)	6.505
Melting point (C)	1830±40
Specific heat (cal/gm/deg C)	0.067
Linear coefficient of expansion, at 20 C (per deg C)	10.4×10^{-6}
Thermal conductivity, 125 C ($cal/cm^2/sec/cm/deg\ C$)	0.035
Electrical resistivity, 20 C (microhm-cm)	56
Modulus of elasticity (psi)	14×10^{6}

Properties and Production Characteristics: Like other metals, zirconium possesses its own characteristic combination of properties which make it suitable for particular engineering applications. Its mechanical properties are similar to those of titanium and, like titanium, are dependent to a degree on the method of production and fabrication, and are affected by variations in oxygen, nitrogen and hydrogen contents. The physical properties of commercial zirconium metal are listed in TABLE 1.

Zirconium has low thermal and electrical conductivity accompanied by a rather low thermal coefficient of expansion. Despite its high melting point, zirconium is not an elevated temperature material. At temperatures above aproximately 1200 F, zirconium reacts with atmospheric gases by dissolving them and by forming a characteristic scale. Prolonged exposure to elevated temperatures, therefore, should be avoided, since these dissolved gases cause increased hardness and strength and reduced ductility.

Machinability of zirconium is comparable to that of titanium or stainless steel. Although information concerning the fabrication of zirconium is somewhat limited, it can be fabricated by most of the methods commonly employed for other metals. Cold forming of annealed material using bend radii equal to 7.5 times the metal thickness is quite practical. Experience to date has shown that warm forming also may be used to advantage in much the same manner as is being currently used with

Table 2—Corrosion Properties of Zirconium, Titanium and Tantalum

Chemical	Zirconium			Titanium			Tantalum		
	Concentration (%)	Temperature (C)	Rating*	Concentration (%)	Temperature (C)	Rating*	Concentration (%)	Temperature (C)	Rating*
Hydrochloric acid	Dilute	All	E	5-conc.	35-100	P	19-conc.	19-100	E
	Conc.	Room	E						
	Conc.	Boiling	E						
Nitric acid	10-conc.	19-100	E	5-conc.	35-100	E-F	Conc.	19-86	E
Oxalic acid	1-25	100	E	1-25	35	E	Sat'd.	Room-96	E
				1-25	100	P			
Phosphoric acid	10-85	Room	E	1-85	19-100	F-P†	85	145-210	E
	10-85	100	E-S						
Sulphuric acid	10-96	19-100	E-P§	5-65	19-35	G-P‡	20-conc.	19-300	E
Sodium hydroxide	10, 50	Room-100	E-G	10, 40	80, Boiling	G	5-40	100-110	E-P
Potassium hydroxide	10-40	Room-100	E	...	.....	....	5	110	E
							40	110	P

*Corrosion resistance: E—excellent (≤3 mil corrosion per year); G—good (3-6 mil/year); F—fair (12-25 mil/year); S—slight (25-50 mil/year); P—poor—not recommended (≥50 mil/year). †E in dilute at room temperature. §E in dilute; P in hot concentrated. ‡G in dilute; P in concentrated.

titanium. Although zirconium reacts readily with atmospheric gases at elevated temperatures, arc welding can be accomplished satisfactorily if the welding area is adequately shielded during the welding operation by an inert gas such as helium or argon. Zirconium metal can also be readily welded by the resistance method, and procedures for brazing this material have been determined.

Present and Future Uses: Because of the extreme combustibility of zirconium metal in fine powdered form, it has found use for priming explosives and flash powders. Massive zirconium, however, is not dangerous and shows no tendency towards burning. The high affinity of zirconium powder for oxygen and nitrogen make it ideal as a getter in vacuum tubes where the zirconium combines with the last traces of undesirable gases remaining in such tubes. Various other applications for this metal in the electronic field have been proposed, such as grid wires in vacuum tubes, electrodes in fluorescent tubes, and in high-intensity electric lamp filaments. And, of course, zirconium also is used to advantage as an alloying addition to both ferrous and nonferrous products.

However, that property of zirconium metal resulting in the largest engineering attractiveness of this material is its excellent resistance to corrosion. In locations where corrosive media are involved and where increased service life and reduction of maintenance costs are desired, zirconium offers many advantages as a material of construction. Zirconium exhibits unusual resistance to corrosion by most of the organic acids and metal chlorides. It is extremely resistant to sea water and sea atmosphere. It also has good resistance to attack by strong alkalies, in which respect it surpasses tantalum. Comparative corrosion data in a few media for commercial zirconium metal with titanium and tantalum are presented in TABLE 2. Although these data were obtained under laboratory conditions, field tests, which are the criterion of metal's performance in a given application, have in a number of cases duplicated the results.

In many instances where the corrosion resistance of zirconium very much surpasses that of other common metals, titanium is equally as good. However, in those chemical processes which involve hydrochloric acid in one step or another, titanium is inadequate whereas zirconium is excellent.

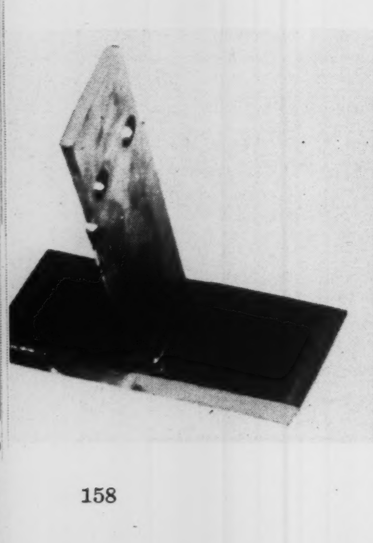


Fig. 2—Autoclave agitator arm, an application in which abrasion and corrosion resistance are both of prime importance

Because of its excellent resistance to nearly all forms of corrosion, commercial zirconium metal should find a wide variety of applications in the chemical and allied industries. In hydrochloric acid processing equipment and in plastics manufacturing, where hydrochloric acid is an intermediate product, there are many opportunities for the employment of zirconium metal. A typical zirconium part, an agitator arm intended for service in a concentrate oxidation autoclave where both abrasion and corrosion resistance are of prime importance is shown in *Fig.* 2. Another attractive field of application is in containers and tanks where contamination of the contents is produced by a small amount of solution of the metal container, although the metal from a corrosion rate standpoint alone might be considered satisfactory. Here, zirconium would be an acceptable construction material by preventing the introduction of even a small amount of deleterious metal salts. Zirconium has also been applied advantageously as a patching material for glass-lined tanks which are commonly used in the chemical industry where particularly corrosive materials are encountered.

Design Economics: Although zirconium is slightly more expensive than titanium, it is considerably less expensive than some materials currently being employed for corrosion resistance. While it would be economically unsound to recommend replacement of steel, copper, aluminum, etc., with zirconium unless the improvement in properties would justify the additional expense, frequently the higher cost of the zirconium can be amply justified by the increased service life and reduction of maintenance costs and down time resulting from the high corrosion resistance of this material.

Despite the advantage of the lower corrosion rate of zirconium metal, direct subsititution of a zirconium part for one of another metal may not necessarily accomplish the greatest economy. When the use of zirconium is considered as a replacement for some more corrosive material, the design of the unit already operating but produced from the other material should also be considered. For instance, thickness of the sheet being used may be reduced where the corrosion rate of zirconium is vastly superior. Maximum economy can only be accomplished when the design engineer becomes familiar with the properties of this new material and designs accordingly.

The engineering potentialities of this new corrosion-resistant material are still the object of many investigations aimed at the adaptation of the metal to a multitude of uses. It is felt that as engineers become more familiar with the various aspects of zirconium metal, it will serve increasingly among the useful products of the metal industries.

Endurance at high temperature is the outstanding property of one of the newer cemented carbides . . .

TITANIUM CARBIDE

By John W. Graham *Research Engineer*
Kennametal Inc., Latrobe, Pa.

EXHIBITING property combinations unique among materials, cemented carbides can be prepared in many formulations and processed by a variety of methods. The wide choice of resulting properties parallels the extensive range of metallurgical phenomena possible with ferrous and nonferrous metals.

The tungsten carbide materials lead the carbide family by their conquests in the metal-cutting industry. However, titanium carbide base materials are being developed for high temperature applications where it has exceptional oxidation resistance as well as strength and structural rigidity. The two carbide materials are fabricated by the same powder metallurgy processes with certain minor variations. Hence cost relationships are comparable. Mass production methods are used on many standard items; fabrication of small numbers of complicated or specialized shapes to designers' specifications is also common practice.

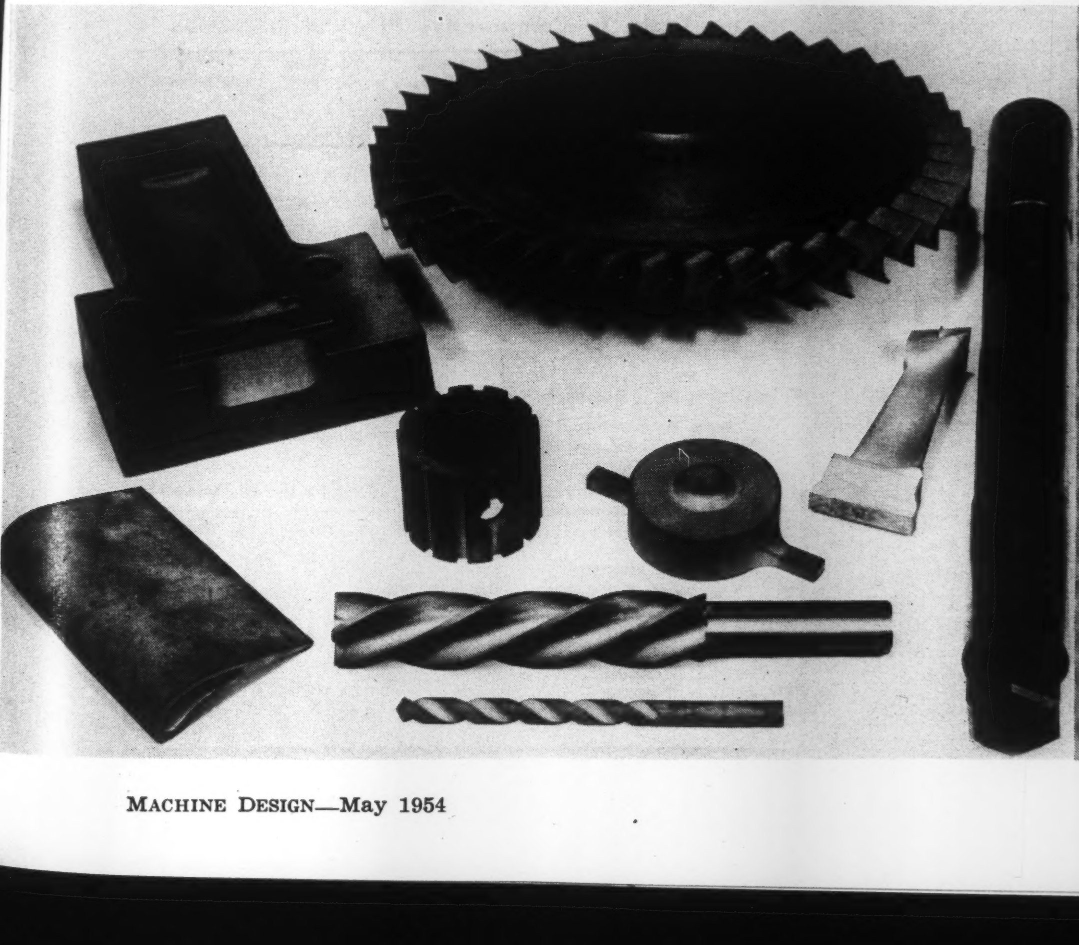


Fig. 1—Parts of complicated shape processed from tungsten carbide and titanium carbide by powder metallurgy techniques

Briefly, the manufacturing process is as follows: Crystalline carbides of refractory metals, such as tungsten, titanium, columbium and tantalum, are ground to very fine particle sizes and blended in the required proportions with a suitable auxiliary metal, or binder, such as cobalt, nickel or ferrous alloys. The powdered mixtures are next formed to the desired shape by pressing, extruding or machining from pressed slugs, then sintered in electric vacuum furnaces at high temperature.

The resultant product—very hard and refractory—is used in the molded state if dimensional accuracy and surface condition are suitable, or ground by diamond wheels for greater precision in size or form.

High hardness, usual transverse rupture and crushing strength, high modulus of elasticity, great resistance to corrosion and abrasion, notable torsional strength, and susceptibility to a high polish by virtue of its close-grained structure are properties that fit tungsten carbide and titanium carbide for applications where great durability is essential.

There are many compositions, or grades, of these carbides in which physical and mechanical properties are differently combined to afford a wide selection of materials for specific uses of varied requirements.

The metal-cutting grades are basically the tungsten carbide types which in view of their high hardness, great strength and long wear resistance are being used as metal-cutting tools in quantities costing several million dollars annually. The tool edges stand up against the wear of such difficult to machine materials as chrome-nickel forgings above 350 brinell hardness, where they remove as much as a ½-inch deep cut at 120 surface feet per minute and a feed rate of 0.027-inch.

There has been an increasing interest in the use of tungsten and titanium carbide materials as structural components which often require tensile strengths up to 180,000 psi or compressive strengths in the order of 500,000 psi. The accumulated experience in tool and die applications has shown that when all design features are considered, these cemented carbides can be used as valve cam follower wear-resistant tips, tube expansion mandrels, chuck jaws, riveting hammers, chain link hammers and other applications where toughness, wear resistance and galling resistance are prime requisites. Many tungsten carbide grades with and without additions of titanium carbide are used for both metal cutting (blanking) dies; metal forming dies such as cupping and deep drawing; metal and extrusion dies; metal foil rolls; swaging dies; ceramic press forming and extrusion dies; ceramic, asbestos and coal pulverizing hammers; rock bits, drill bits, coal cutting machine bits, etc.

High Temperature Service: The heat resistance of tungsten carbide under conditions encountered in metal-cutting is well-known, as standard grades will withstand considerably higher temperatures if the atmosphere is not too highly oxidizing. However, in response to the demand for a heat-resistant material superior to any of the familiar cast alloys,

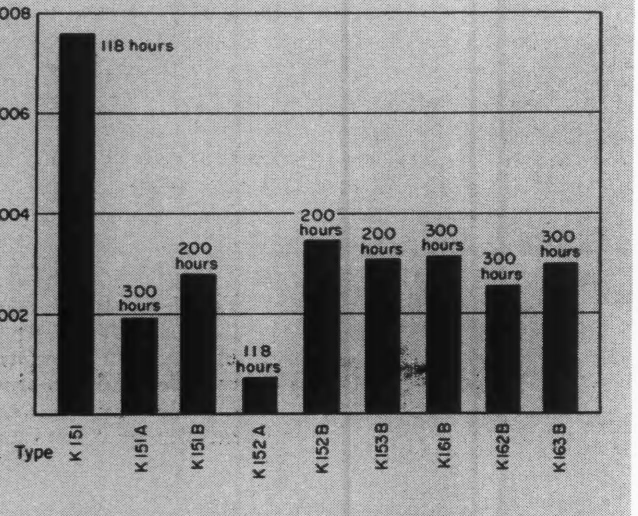


Fig. 2—Oxidation characteristics at 1800 F of typical titanium carbide compositions. Presented for comparison, type K151 is not designed for high-temperature service. Other types contain oxidation-inhibiting additive which aids formation of an impervious oxide coating

Table 1—Comparative Physical Properties

Property	Titanium Carbide	Tungsten Carbide	Superalloys (Several Co-Cr-Ni and high Ni-Cr alloys)
Room Temperature			
Density (gm/cc)	5.5-6.5	11.9-15.1	8.3-8.7
Hardness (Rockwell A)	80-93	85-93	61-65
Modulus of elasticity (psi)	$35\text{-}60\times10^6$	$61\text{-}90\times10^6$	30×10^6
Compressive strength (psi)	550,000	518,000-800,000	....
Conductivity			
Thermal (cal/deg C/cm/sec)	0.072-0.085	0.068-0.207	0.035-0.065
Electrical (% copper std.)...	1.9-5	4.3-9.4	1.37-1.8
High Temperature			
Thermal Expansion (in/in/deg F to 1200 F)	$4.3\text{-}6.2\times10^{-6}$	$2.5\text{-}4.0\times10^{-6}$	$6.73\text{-}8.5\times10^{-6}$
Oxidation Resistance at 1800 F	Excellent (see *Fig.* 2)	Poor	Good
Tensile strength			
(psi) 70 F	80,000-150,000		110,000-180,000
1500 F	55,000		52,000-73,000
1600 F	47,000		34,000-51,000
1800 F	40,000		9,000-25,500
2000 F	30,000		13,100
2200 F	12,500		
2400 F	3,000		

and conventional carbides, a series designated Kentanium has been developed which uses essentially titanium carbide instead of tungsten carbide as the matrix compound.

Extensive tests have shown that while the titanium carbides are basically similar to tungsten carbide in such properties as high modulus of elasticity, hardness and resistance to wear, low thermal expansion, and many other characteristics, they possess additional properties which greatly extend the traditional fields of carbide applications.

Titanium carbide is made by procedures similar to those used for tungsten carbide compositions. Its principal ingredient is pure titanium carbide. Cobalt was the first auxiliary metal used but it has since been found that nickel is superior. Alloys of the ferrous group can be used as binders for certain properties.

The general properties of titanium carbide are compared with tungsten carbide and several superalloys in TABLE. 1. For purposes of the table, properties of titanium carbide grades containing 10 to 40 per cent nickel are grouped together. Properties of typical titanium carbide compositions are detailed in TABLE 2.

The low density of titanium carbide in comparison with the superalloys is immediately apparent. In rotating parts the centrifugal stresses are proportional to material density; thus, stress from this cause with titanium carbide is about two-thirds that developed with ferrous alloys.

Hardness is high, thereby indicating good wear resistance. Certain applications to be described later indicate that a large amount of the hardness is retained at high temperature. Likewise, compressive strength is high and remains high in a great degree at temperatures where refractory alloys deform plastically.

Young's modulus of elasticity approaches that of cemented tungsten carbiden and is about double that of ferrous alloys. This, of course, means approximately half the elastic movement developed on alloys for a given stress.

The electrical resistance increases with temperature, corresponding to changes in metallic thermal conductivity, thereby indicating that the material has definite metallic characteristics.

Thermal conductivity of titanium carbide is superior to that of the superalloys. This, together with low thermal expansion, accounts for the superior performance of titanium carbide in thermal shock tests.

Titanium carbide retains more of its tensile strength as temperature is increased than do most of the refractory alloys.

Oxidation resistance of the commercially produced compositions is adjusted to the requirements of the application, *Fig.* 2. In a short time, those grades having the best oxidation resistance form a thin tenacious and impervious oxide coating which resists further oxidation for hundreds of hours at temperatures of 1800 F and up.

Types and Applications: Slight changes of composition in cemented carbides affect certain specific properties without changing the general engineering characteristics of the material. For example, the addition of columbium-tantalum carbide improves the oxidation resistance many-fold without appreciably changing density, hardness, and strength. However, like changes in the binder content affect the microstructure, toughness, modulus of elasticity, hardness, and thermal shock resistance. Small alloying additives in the binder phase can improve the high temperature stress-rupture strength by a factor of a 100 per cent. Variations in carbon content influence greatly the physical strength characteristics of the sintered compacts. It is only by constant evaluation that these variables can be deliberately adjusted to provide optimum values of compatible and desirable characteristics.

The influence of metallurgical changes can be discussed with several practical examples of their use in industrial applications. For differentiation the (Kentanium) type designations are used here, as in the tables and figures. The binder content in the titanium carbide series increases as the last digit of the designation increases. A higher binder content gives greater ductility and resulting toughness with commensurate increase in thermal shock resistance. The designation suffix indicates relative

Table 2—Characteristics of Typical Titanium Carbide Compositions

Type	Density (gm/cc)	Hardness (Rockwell A)	Modulus of Rupture Strength (psi)	Tensile Strength (psi)	Modulus of Elasticity (psi)	Coefficient of Thermal Expansion (in./in./deg F x 10^{-6})	Thermal Conductivity (cal/deg C/cm/sec)
K151	5.5	89.5	190,000	......	....	...	.....
K151A	5.8	89.5	175,000	......	57,000,000 (sonic test)	4.28	.....
K151B	5.7	89.5	150,000	95,000	49,000,000	...	.....
K152A	6.2	84.5	150,000	......	....	...	.....
K152B	6.0	85.0	210,000	100,000	47,000,000	...	0.0768
K153B	6.3	82.8	185,000	150,000	41,000,000	5.8	.....
K161B	5.7	90.2	165,000	76,000	60,000,000	...	.....
K162B	6.0	89.0	230,000	130,000	59,000,000	5.3	0.0724
K163B	6.2	87.4	210,000	130,000	56,000,000	5.4	.....

oxidation resistance, the letter "A" indicating most resistant to oxidation.

For example, K150A is a low binder material having excellent oxidation resistance. This grade has been useful as a glass lens blank forming mold where hot plastic glass is press formed.

Type K151A contains a greater amount of binder and has been useful as a glass tumbler forming die in a similar manner. The larger size of the mold requires better thermal shock resistance commensurate with an oxidation resistance coating that should not adhere to and contaminate the clear glass.

This composition is also used successfully as a spot welding anvil where the oxide coating prevents metal adherence in a small size which resists the rapid thermal shock. This grade has also been used as a hot spinning tool in appreciable quantities. Its good thermal shock resistance in small shapes, its resistance to metal adherence and plastic flow are necessary to resist the abrasion of low carbon and stainless steel tubes which are heated to temperatures of 1900-2000 F for the production of parts by spinning.

Type K152B has exceptional tensile strength, thermal shock and slagging resistance when used as scarfing torch protective rings. The torches are used to burn out slag inclusions on the surface of steel ingots and slabs prior to finish rolling. The slag tends to ruin the expensive scarfing torches, the lives of which are extended many-fold by the protection given them by small titanium carbide shoulder rings.

A more abusive application is that of steel rod mill guides which must withstand considerable thermal and mechanical shock as well as high temperatures and friction wear. Type K153B inserts have saved thousands of dollars in machine down time by extending the normal life of three or four hours to over 1000 hours before replacement becomes necessary.

Type K162B is one of a series containing small alloying additives in the binder phase and supplies extreme high temperature stress-rupture resistance, *Fig.* 3. This grade resists tensile stresses at 1600 F and 1800 F double that resisted by several superalloys for hundreds of hours. It is also useful as corrosion and wear-resistant balls and seats in oil well pumps. Balls of this type have withstood months of corrosion where special alloys have failed in a few days.

These described grades are resistant to attack by molten sodium, a coolant used for heat transfer in atomic energy nuclear reactors. Other potential applications exist in atomic energy, jet engines, industrial gas turbines, electronics, and fields where any one or combination of high stress resistance at high temperatures, oxidation resistance, and other pertinent properties are better satisfied by the cemented carbides.

Several applications for which these materials are being evaluated are as engine valves, valve seats, balls for hot hardness testing, bushings, and flame tubes. They have been used as hot tensile test heads, pressure sleeves and anvils for high-temperature transverse rupture test units. A successful room-temperature application is for gage rings that are ground and polished to close tolerances from high binder compositions having thermal expansion characteristics which approach those of ferrous alloys.

It is only by a careful evaluation of all engineering requirements that the most suitable type may be specified for use. For best life, a type is usually recommended that gives optimum property combinations instead of a maximum value obtainable on a single and perhaps the most important physical characteristic specified by the user.

The mentioned examples of cemented-carbide uses give an indication of the relative variety of shapes and sizes which can be made. Large and small parts of complicated shapes can be made, such as by lathe turning using diamond pointed tools, or by machining complicated cuts on milling machines using high-speed abrasive wheels for cutters, by extruding plasticized carbide from 0.004-inch to 2 inches in diameter, or by pill pressing single shapes where large quantities justify die costs.

Newest of the foamed plastics, and just beginning to find widespread applications, are . . .

FOAMED VINYL PLASTICS

By R. A. Calsibet *Asst. to Manager, Surface Coatings Div.*

Bakelite Co., Div. of Union Carbide and Carbon Corp., New York

FOAMED vinyl plastisols, a relative newcomer to the field of foamed plastics, are assuming an important role in the design and production of foamed products. The excellent physical and chemical properties of vinly resins, coupled with their ease of handling, have led to an ever-increasing number of applications for the foamed plastisols; their wide acceptance is reflected in the rapidity with which manufacturing techniques have passed from the laboratory to the plant.

Vinyl dispersion resins, such as bakelite vinyl resin QYNV and VYNV, are characterized by exceptional resistance to organic acids, alkalies, and oxidizing agents, and are not dissolved by greases, oils, alphatic hydrocarbons, alcohols or glycols. These advantageous qualities of vinyl resins are imparted to the dispersions, or plastisols, formulated with them. Since plastisols are fluid dispersions in which the entire liquid phase consists of plasticizer, there is no volatile loss in converting to a flexible, resilient solid. These plastisols are especially well suited for the preparation of both open and closed-celled sponge from which structural and nonstructural foamed products can be made; the cellular products are resilient, flexible and easily fabricated, *Fig.* 1. Flame and chemically resistant foamed vinyls, *Fig.* 2, have exceptional tensile strength, are resistant to abrasion and tearing, provide good shock-absorption characteristics, and do not harden or dry out upon aging.

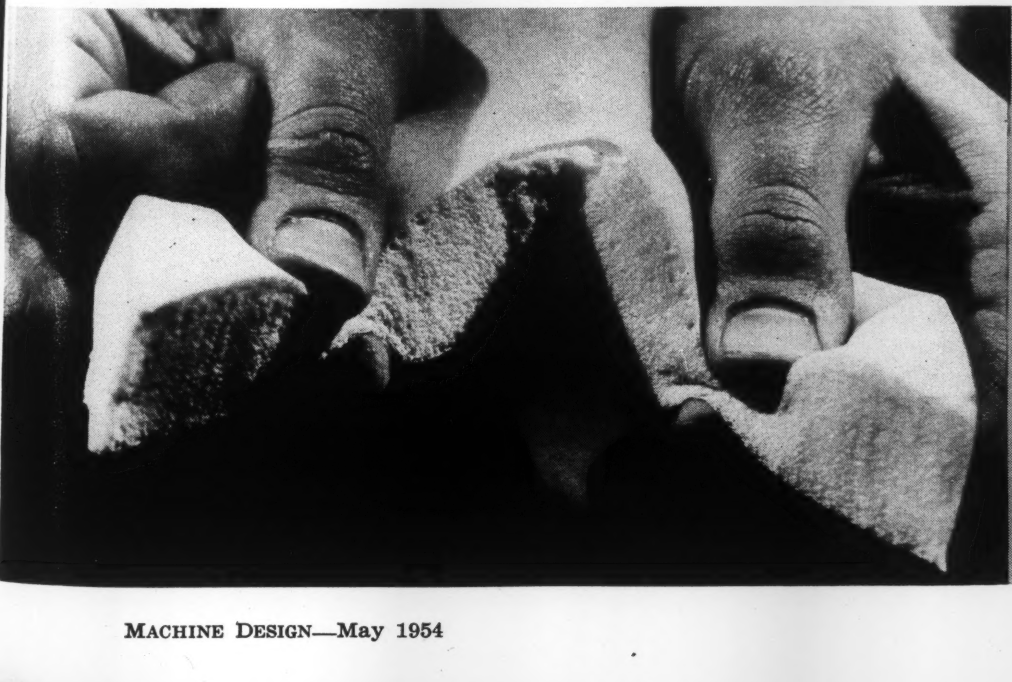


Fig. 1—Resilient and flexible, foamed vinyls have excellent tear resistance

Foamed vinyl resin plastisols may be classified in two groups according to type of cellular structure. The first group has a structure consisting primarily of connected cells; materials of this group will pick up water in the same manner as a sponge. Cellular structure of the second group is almost entirely composed of unconnected cells; these materials do not act like a sponge and are often used for flotation applications. End use of foamed vinyl plastisols is generally dependent upon the cellular structure of the material.

Method used in converting the vinyl compound to its final fused state determines the cellular structure. When free expansion is allowed during fusion through the lack of external pressure or use of minimal pressure on the material, a connected cell type of foam results. Foamed products of this type do not require further processing after fusion. Unconnected cellular material is fused under pressures of approximately 2000 psi, with expansion occurring by means of further heat-processing after it has been released from the mold. Density of both types can be varied over a wide range; the unconnected cellular type can be produced with a density of approximately 5 to 6 pounds per cubic foot while the density of the connected cellular type is in the range of 6 to 10 pounds.

Production Methods: At the present time, connected cell vinyl foam can be produced by two methods. The first of these is by mechanically "whipping" a gas, such as nitrogen or carbon dioxide, into the plastisol while under pressure. A continuous foaming and curing process based on this method has been patented by Elastomer Chemical Corp. for use by licensees. In this process the plastisol is metered from a storage tank into a continuous mixing unit where, with vigorous agitation, a gas is absorbed into the compound. Forced out into open or closed molds, *Fig.* 3, or onto conveyor belts by the gas pressure, the foamed material can be cured at relatively low temperatures. While curing can take place in conventional hot-air ovens, the use of high-frequency heaters materially reduces the curing time of thick sections and facilitates the production of continuous vinyl foam sheeting.

The second method used is chemical expanding of the vinyl compound. This process generally util-

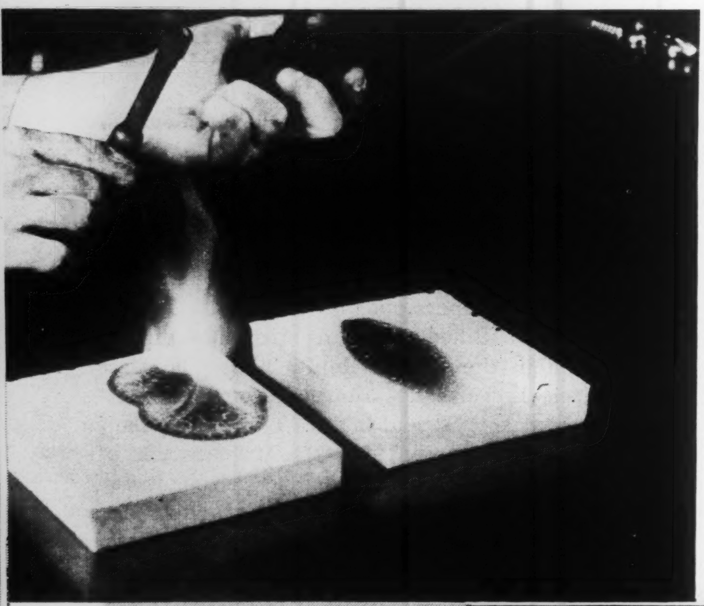


Fig. 2—Above—Ignited in identical manner, foamed vinyl block, right, is self-extinguishing while the foam rubber block continues to burn

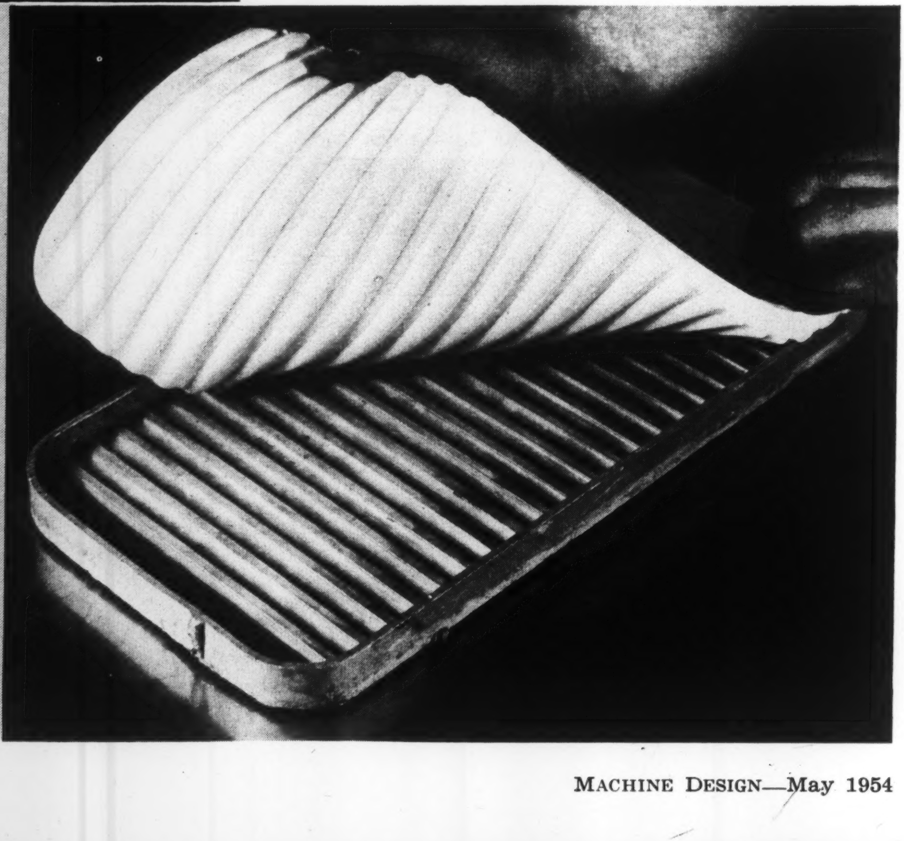


Fig. 3 — Right — Foamed vinyl with connected cell structure can be produced in open mold, with good reproduction of mold detail

izes low-pressure molds and blowing agents such as sodium bicarbonate, ammonium carbonate, commercial nitrogen foaming agents or, in cases where toxicity is not a problem, compounds such as diazoaminobenzene. With the application of heat these powders are converted into gas which, in turn, sponges or foams the plastisol.

Both methods allow the material to be foamed at atmospheric pressure and fused by a single-phase heat treatment. Since neither pressure nor molds are required in the manufacture of this type of foam, the product may be moved directly by conveyor belts, thus opening a new approach to the production of continuous unsupported or cast sheeting. After fusing, the connected cellular type product is covered with a thin, unfoamed skin.

Foamed vinyls having primarily an unconnected cell structure are prepared by incorporating a commercial foaming agent, usually of the nitrogen liberating type, into the vinyl dispersion by stirring or grinding. Molds are completely filled with the compound before foaming. In commercial practice either steel molds capable of withstanding internal pressures of 2000 psi or thin sheet-metal molds, which are subsequently placed in a heavy container constructed to withstand the same pressure, can be used. In the latter method, space remaining around the mold or molds is filled with the foamable vinyl compound, thereby equalizing the pressure inside and outside the mold when the blowing agent liberates gas. The product is chilled prior to its removal from the mold and, after removal, is gradually warmed. As it softens, it expands a controlled amount to the final, undistorted size. These unicellular products have a much thicker outer layer of unfoamed material, of definite advantage in flotation applications.

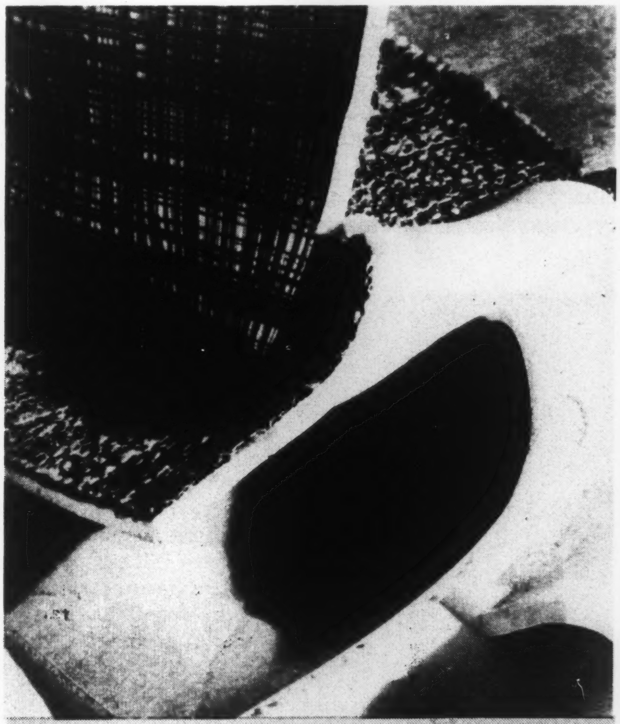


Fig. 4—For cushioning, padding and interior coverings the foamed vinyl can be laminated to natural or synthetic fibers, textiles, or vinyl film and sheeting

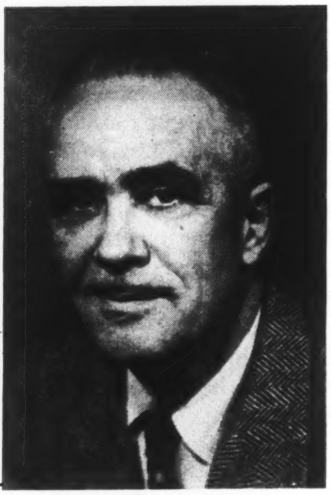
Applications for Foamed Vinyls: Potential applications for vinyl foam plastics may be considered to be all present uses for cushioning products and for sound, shock and vibration-absorbing media. Inherent characteristics of vinyl chloride resins immediately suggest many uses, TABLE 1. Perhaps the largest applications at present for the connected cellular type are in cushioning materials, *Fig.* 4, and molded inserts. Buoyancy, moisture resistance, salt-water resistance, grease resistance and oil resistance of foamed vinyl make the unconnected cellular type particularly adaptable for marine equipment, and as floats for valves, gages, and carburetors. Foamed vinyls are also being employed as rollers, gaskets, insulation, and in sandwich construction.

Development work on vinyl foam is following several lines of activity which involve many new applications. Both automotive and refrigerator parts manufacturers are conducting extensive reseach on new uses. Relatively small quantities of intricately molded products can be economically produced with the use of inexpensive, thin-walled molds. More immediate markets for these products undoubtedly lie in military, transportation and industrial equipment. Superior aging properties of vinyl foam, combined with a wider temperature range of usefulness, offset present slightly higher initial cost. Flame-resistant qualities, a property not usually associated with other widely accepted foam products, also point toward the eventual use of foamed vinyls in many cushioning applications.

Table 1—Potential Applications for Foamed Vinyls

Aircraft: interior wall covering; padding for heat, sound and vibration damping; seats
Automobiles: crash pads, seats and armrests, welting
Boats: cushions and seats; buoyancy filler for small-boat compartments; heat, sound and vibration damping material for submarines and naval craft
Bus seats
Electrical insulation
Supports for electronic and other delicate instruments
Floats for valves, carburetors and gages
Refrigerator door seals
Gaskets and packing materials
Crash pads for gun mounts and tank interiors
Grommets
Trucks: body lining; seats; heat, sound and vibration damping
Tires for small wheels
Sandwich constructions
Self-sealing gasoline tanks

Long used in repair applications, a "new" tool is placed in the hands of designers with . . .



SPRAYED METALS

By D. A. Watson *Metallizing Engineering Co. Inc.*

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MANY people still think of metallizing as being "new." Actually the first crude prototype of the modern metallizing machine was built in Europe over 40 years ago. Possibly the first unit to appear in this country was taken from a German ship interned in San Francisco during World War I. What then retarded this process during its early years?

The answer was patent restrictions, exorbitant rental fees, little printed information, nonexistent instruction facilities, plus equipment that can only charitably be described as slow and temperamental. Added to these factors were numerous attempts to do the impossible, plus failure of much perfectly good work because of grossly improper procedures. With the importing of the first few foreign spray guns, the age-old attitude of "let the buyer beware" was the rule and not the exception. Little wonder that the designer, faced with all the problems of translating an idea into a workable piece of equipment, should pass over such a process no matter how potentially attractive it might seem to be.

The first domestic metallizing unit was designed and built in this country over 25 years ago. Spraying less than 2 pounds of steel per hour and difficult to operate, it was crude by any modern day standards. Gradually, however, as in every other machine tool, the improvements came. A few of these were larger and more efficient turbines, enclosed pump-lubricated gears, self-balancing siphon type gas heads, automatic centrifugal governor con-

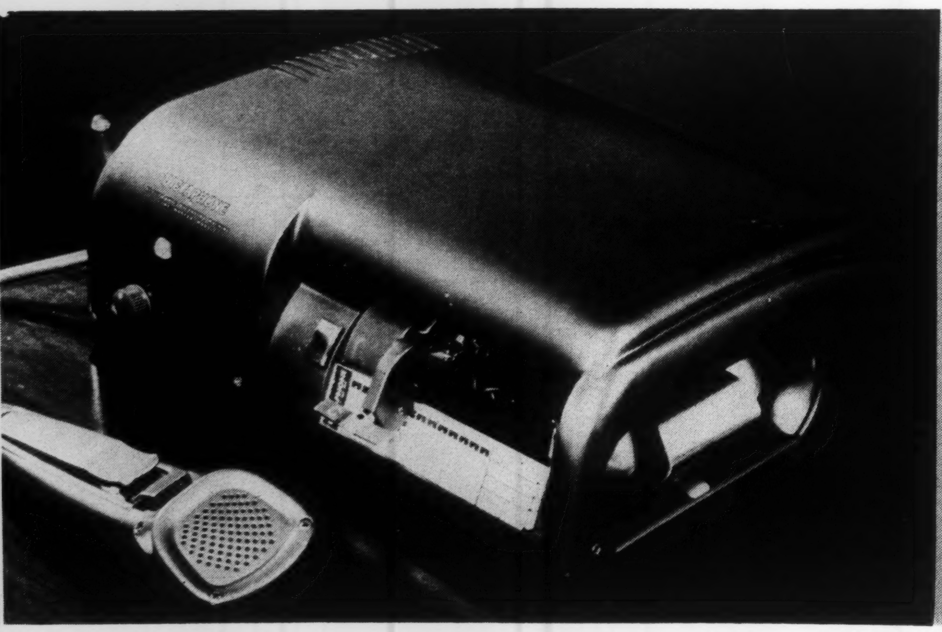


Fig. 1—Sprayed zinc shields closely positioned components in the Dictaphone dictating machine. Plastic parts, "transparent" to radiations in the audio-frequency range, are metallized, then grounded to the chassis

trol of wire speeds, heavy-duty production machines and better metals. A mass of information on practical work and operating procedures was established. Surface preparation, selection of proper metals and finishing recommendations became standardized. All of these data are now available in individual industrial bulletins, instruction manuals and handbooks.

Probably the greatest impetus to metal spraying came as a result of World War II. Hundreds of metallizing installations were used in the direct manufacture of planes, engines, guns, tanks and ships. Even more went to every branch of the armed services for maintenance of equipment during field use. One production example should suffice; many others could be cited.

Cooling vanes on the cylinders of all radial air-cooled aircraft engines were coated with 0.004-inch of aluminum for prevention of rust. Some 15 fully automatic machines costing over $25,000 each were made for this purpose. Originally designed to turn out a cylinder in a minute and a half, they finally were producing one every 45 seconds. There is a little interesting sidelight in the design evolution of such equipment. The author sprayed the first production cylinder by hand at the Wright Aeronautical Corp. in Paterson, N. J., over 15 years ago. It was a matter of spinning a manual turntable with the left hand while holding a spray gun in the right and took, if memory serves, about 8 minutes per cylinder.

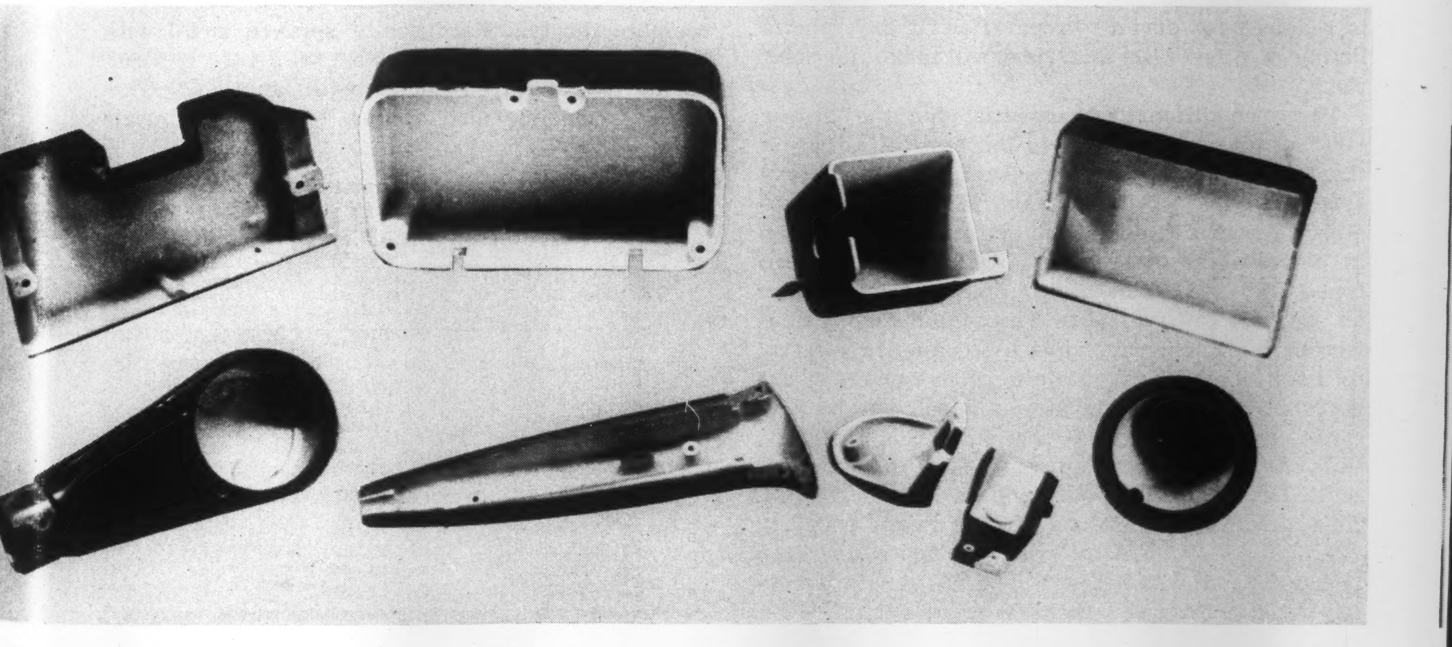
Table 1—Hardness of Sprayed Metal

Metal	Rockwell Hardness	Metal	Rockwell Hardness
Aluminum	72 H	Nickel	49 B
Babbitt	58 H	Stainless, soft	78 B
Bronze, aluminum	78 B	Stainless, hard	29 C
Bronze, commercial	18 B	Iron	80 B
Bronze, manganese	27 B	Steel, 0.10 C	89 B
Bronze, phosphor	20 B	Steel, 0.25 C	90 B
Bronze, Tobin	27 B	Steel, 0.80 C	36 C
Copper	32 B	Tin	10 H
Monel	39 B	Zinc	46 H
		Molybdenum	38 C

After the war thousands of trained technicians returned to civilian pursuits. Now, and really for the first time, the machine designer and production man had something to work with in manpower, up-to-date data and equipment to do the job. Very quickly the results began to show and metallizing took its rightful place. This article will take a look at some of the more basic characteristics of the present-day process and the end results to be expected, *Fig.* 1.

What Are Sprayed Metals: Sprayed metal is a metallurgical material having entirely different physical and chemical properties than those of the original wire. This fact should be borne in mind at all times when considering metallizing's suitability for any specific task. In general, sprayed metal contains some oxide, is harder, more brittle and more porous than its equivalent in cast or drawn metal. These characteristics make it ideal for a bearing surface because of oil retention in the pores. Conversely, it is not good for cathodic corrosion protection using such metals as stainless steel, nickel or bronze. Corrosion protection is obtained by using anodic metals—generally zinc or aluminum. These, being sacrificial, protect by electrolytic action and porosity is of no importance.

A great deal of laboratory time and money has gone into attempting to determine just what makes sprayed metal "stick." While this work is still continuing, it must be admitted that the mechanism of particle attachment to the base and to each other is not yet exactly known. There is great mechan-



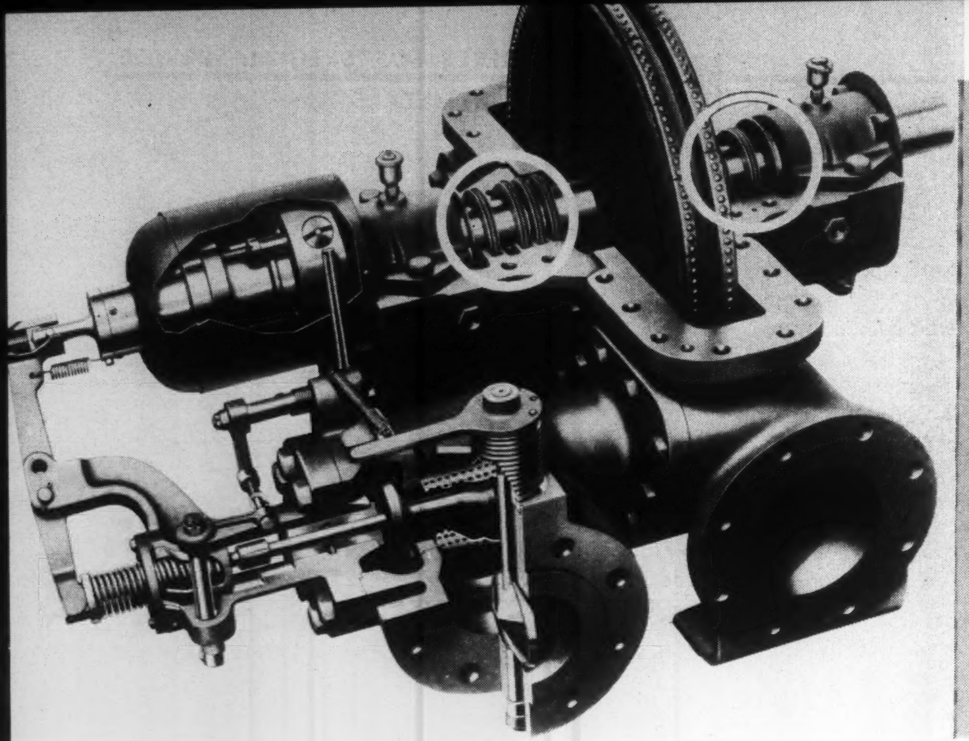


Fig. 2—High chrome-nickel steel sprayed on the shaft at the two gland zones of this Westinghouse turbine prevents corrosion and rust-cutting of the carbon gland segments

ical interlock between particles and even a minor amount of welding at some points. Manufacturers are careful to describe the bonding as mechanical, however, and not a weld in any true sense of the word. There is also oxide cementation between particles. The physical properties of sprayed metal, therefore, include the properties of the particles, their cohesiveness for each other, degree of porosity of the coating, and its oxide content. There are a number of other factors but these appear to be primary.

The processing of a normal metallized shaft, *Fig.* 2, or roll will seldom build up heat in excess of 350 F. This value can be kept close to room temperature by various cooling methods if desired. Because of lack of heat, sprayed metal can be applied to almost any base material. This may be oversimplification for the moment. An outline of what is required for surface preparation, if any, plus a listing of a few base materials, can make the point clear.

Three conditions are essential for the proper bonding of sprayed metal to the base. The first of these—perfect mechanical cleanliness—is always necessary. The word "mechanical" is used deliberately in order to differentiate from solvents used in chemical cleaning methods. These have been found to leave an invisible but objectionable film on the part to be coated. The second requirement is roughness when metal is to be applied directly to metal. Methods of obtaining such roughness are now well known in industry and will not be covered here. There is one exception to this necessity. In recent years a new sprayed metal consisting essentially of pure molybdenum has been developed. This metal, when sprayed, has the unique property of bonding itself directly to clean, smooth, and even polished metal. It will not bond well to those containing copper. The third bonding condition requires no preliminary roughening, although the base must still be clean. Metallizing materials will bond sufficiently well to slightly porous structures such as plaster, carbon, unglazed ceramic, or to soft objects made of wood, cloth, paper or hard wax, to allow production applications with these maerials. Straw mats and old lace have actually been reproduced to make plastic molds.

Properties of Sprayed Metal Coatings: One of the most common questions asked about a metallized coating by those proposing to use the process is its hardness compared to the original wire. Rockwell or other common hardness tests, when used on sprayed metal, are influenced by the hardness of the metal particles, their bond to each other, the porosity of the deposit, and the oxide content. Obviously such tests cannot be used to compare the true hardness of sprayed metal with ordinary metal. They can be used only in comparing one sprayed metal with another. This general principle also applies to other materials

Table 2—Strength of Sprayed Metal

Metal	Ultimate Strength (psi)	Strain at Ultimate (%)
Stainless, soft	30,000	0.27
Stainless, hard	40,000	0.50
Iron	28,000	0.25
Steel, 0.10 C	30,000	0.30
Steel, 0.25 C	34,700	0.46
Steel, 0.80 C	27,500	0.42
Aluminum	19,500	0.23
Aluminum, silica	37,000	0.54
Bronze, aluminum	29,000	0.46
Bronze, phosphor	18,000	0.35
Bronze, Tobin	13,000	0.51
Zinc	13,000	1.43
Molybdenum	7,500	0.30

such as sintered powder metal. Table 1 gives Rockwell hardness of a number of sprayed metals. Although 0.80 per cent carbon steel is actually very hard, it has a reading of only Rockwell 36 C. The true particle hardness is 67 C, and the coating will resist nonlubricated wear as well as hardened high-carbon steel, *Fig.* 3. Where the shaft is lubricated, the sprayed metal will resist wear much better than ordinary steel because of the porosity. Attempts have been made to compare sprayed metal hardness by file testing. While some comparison can be made by this method, it has been found that the file tends to tear out particles and hence the method gives a false impression of softness.

From the foregoing it can be realized that many times sprayed metal stands a chance of being disregarded on property values alone when, in all probability, it can offer a completely successful solution. Not so long ago it was thought that the prime requisite for any sliding or rotating bearing surface was extreme hardness and smoothness combined. Now, with the advent of metallizing, sintered metals, and rough chromium plating, the opposite viewpoint is gaining favor. Along these lines is a most interesting test run some years ago. Two identical marine turbines were set up side by side in the maker's plant. One had the customary hard steel rotor shaft while the other had journals of the equivalent sprayed metal. Both were started up and simultaneously deprived of oil. In exactly nine minutes the unsprayed shaft began to overheat and the turbine had to be quickly stopped. One-half hour later the other turbine was still running normally and the test was discontinued. The latter was pulled down, given a rigid inspection, and passed for shipment. Since that time, because of some possible corrosion at the carbon seal ring area, designers have gone a step further; sprayed Monel or stainless steel is now used.

Table 3—Comparative Shrink of Sprayed Metals

Metal	Shrink (in./in.)	Metal	Shrink (in./in.)
Stainless, soft	0.012	Aluminum	0.0068
Stainless, hard	0.0018	Aluminum, silica	0.0057
Iron	0.009	Bronze, aluminum	0.0055
Steel, 0.10 C	0.008	Bronze, phosphor	0.010
Steel, 0.25 C	0.006	Bronze, Tobin	0.0104
Steel, 0.80 C	0.0014	Zinc	0.010
		Molybdenum	0.003

The relation between tensile strength and wear resistance is of particular importance in any proposed use of sprayed metal, *Fig.* 4. Resistance to wear involves many variables such as heat, pressure, lubrication, finish and hardness. The processes of wear occur in two ways: first, by the actual wearing of individual particles; second, by the tearing away of entire particles by abrasive matter or by "welding" in more severe service. This latter type of wear is resisted by particle cohesion. Tensile strength of sprayed metals, Table 2, is a direct function of such cohesion. Because sprayed metal shrinks somewhat during application, Table 3, there are initial internal stresses set up. Tensile tests, therefore, measure the differences between the actual strength and the internal stress. It follows then that the ability of a metal to yield or elongate is of importance. If a metal has a high shrink it may crack, even with high strength. If it has a low shrink it will not crack, even with low strength. Therefore, metals with low shrink, high tensile strength and a relatively high elongation are selected when possible.

Major Applications: For many years the main use of metallizing has been the salvage of worn, damaged or mismachined journals on rolls. Fairly recently, with the establishment of 21 basic proved systems, the field of zinc or aluminum anticorrosion work has become important. Included here are such applications as railroad bridges, tanks, refrigerators,

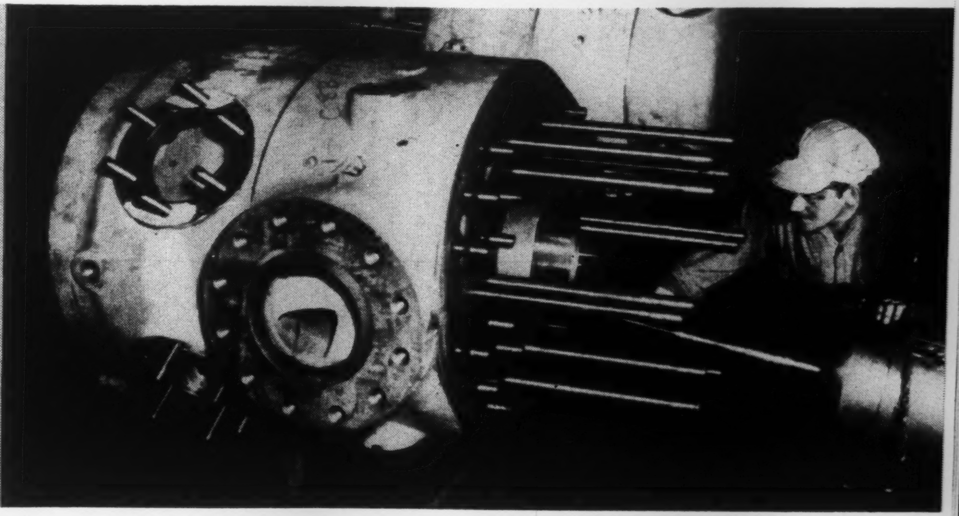


Fig. 3—Carbon-steel piston rods are metallized with a coating of stainless steel in Cooper - Bessemer heavy-duty compressors. Rods must be operated without lubrication in chemical plants to prevent contamination; the coating prevents galling and damage to the packing

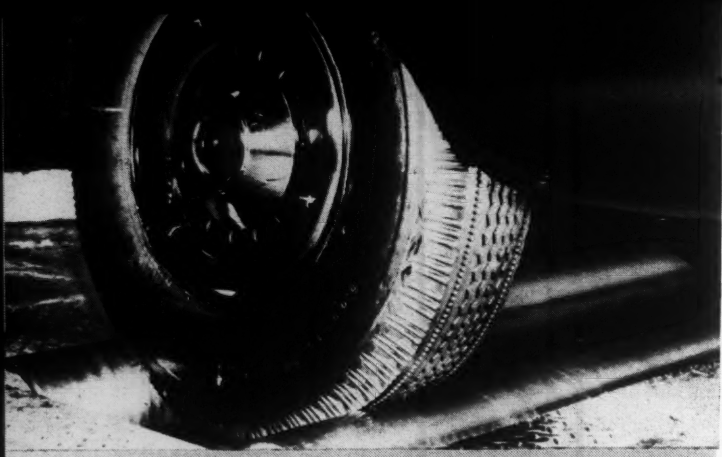


Fig. 4—Rolls which provide drag on wheels of new cars during final tests are sprayed with a coating of steel to prevent wear. Former rolls lasted 3 months; the metallized ones, 4 years

steel dock piling, structural steel, entire hulls and superstructures of small vessels and a host of other items being protected for 10, 20 or even 30 years or longer. Test work is now in progress on large tankers. The third, and fastest growing field for metal spraying, is now its actual use in the original production of industrial equipment of all kinds. Mention of a few typical applications should be informative.

A manufacturer of dictating machines and another of juke boxes and home organs both had the same problem—outside static electrical interference. Previous attempts to use foil had proven costly and not very permanent. Shielding by sprayed zinc solved this cheaply and easily.

A maker of heavy office accounting machines wanted his carriages to have the lightness of aluminum with a bearing surface of steel. Quite simple—the parts are made of aluminum, coated with mild steel and machined to finish dimensions. Here might be the germ of an idea for those dealing with high starting inertia in heavy machinery such as paper mill equipment or newspaper presses.

Carbon resistors and motor brushes need copper at the connecting areas. This is applied by metallizing. Literally thousands a day are fed through automatic handling equipment.

Prior to 1944 a producer of electrical equipment finished outdoor power capacitors with three coats of baked paint. Cracking and chipping caused rust. A metallized zinc coating followed by lacquer for appearance was then adopted. This was so satisfactory that three years later they began using it on indoor equipment as well.

The Army had difficulty with "freezing" of the recoil pistons and cylinders of its tank mounted 90-mm guns. Sprayed aluminum bronze solved this one and is now standard construction practice.

And so it goes—makers of playground and steel mill equipment, textile machinery, ball bearing grinders, air-conditioning units, pleasure cars and aircraft all incorporate versatile sprayed metals into their design specifications.

Thermal endurance, mechanical strength, corrosion and abrasion resistance, and dimensional stability are some of the properties supplied by today's . . .

MECHANICAL GLASS

By Robert L. Edwards Corning Glass Works
Corning, N. Y.

CONTINUAL research and improved production techniques now make possible glass which is lighter than cork or almost as heavy as iron; as strong as steel or as fragile as an eggshell; as soft as cotton or as hard as precious stones. Glass can be resistant to heat and to corrosive acids and it can transmit or absorb infrared, visible, ultraviolet or the X-ray bands of the spectrum. Modern glass can conduct or stop electricity.

Types: Development of a single engineering material which has so many diversified properties is possible because the chemical composition of glass can include combinations of practically every element of the atomic table. The chief ingredient is silica, one of the most plentiful, inexpensive and available raw materials found on earth.

More than 50,000 different glass formulas have been developed by Corning. Of these, the classifications which find greatest use in the production of mechanical components are the borosilicate glasses—relatively simple chemical compositions usually containing approximately 80 per cent silica, 14 per cent boron oxide, 4 per cent soda and 2 per cent alumina. Borosilicate glasses are produced economically and have good mechanical strength and thermal and chemical resistance which make them adaptable to mechanical applications.

Another type used increasingly is the 96 per cent silica glass. Although considerably more expensive than the borosilicates, it is capable of serving under conditions which require constant temperatures as high as 900 C.

Manufacturing Methods: Production of most glasses begins when the raw materials are melted together for long periods of time at temperatures ranging from 1300 to 1600 C. The hot, viscous mixture is then blown, pressed or drawn into the required shape and allowed to cool. The three manufacturing processes can be performed by hand or by automatic machine, depending upon the volume or the intricacy of the operation.

Subsequent production steps frequently include an annealing process in which the glass is heated to a temperature at which internal stresses disappear and cooled slowly to avoid restressing. Or the glass may be tempered by heating to a temperature which sets up controlled compressive stresses in the surface layers and balancing tensile stresses

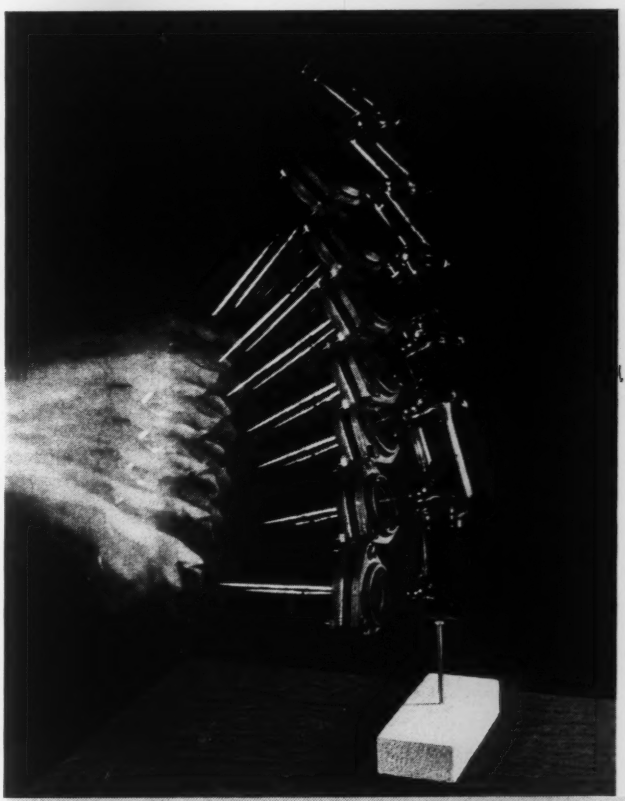
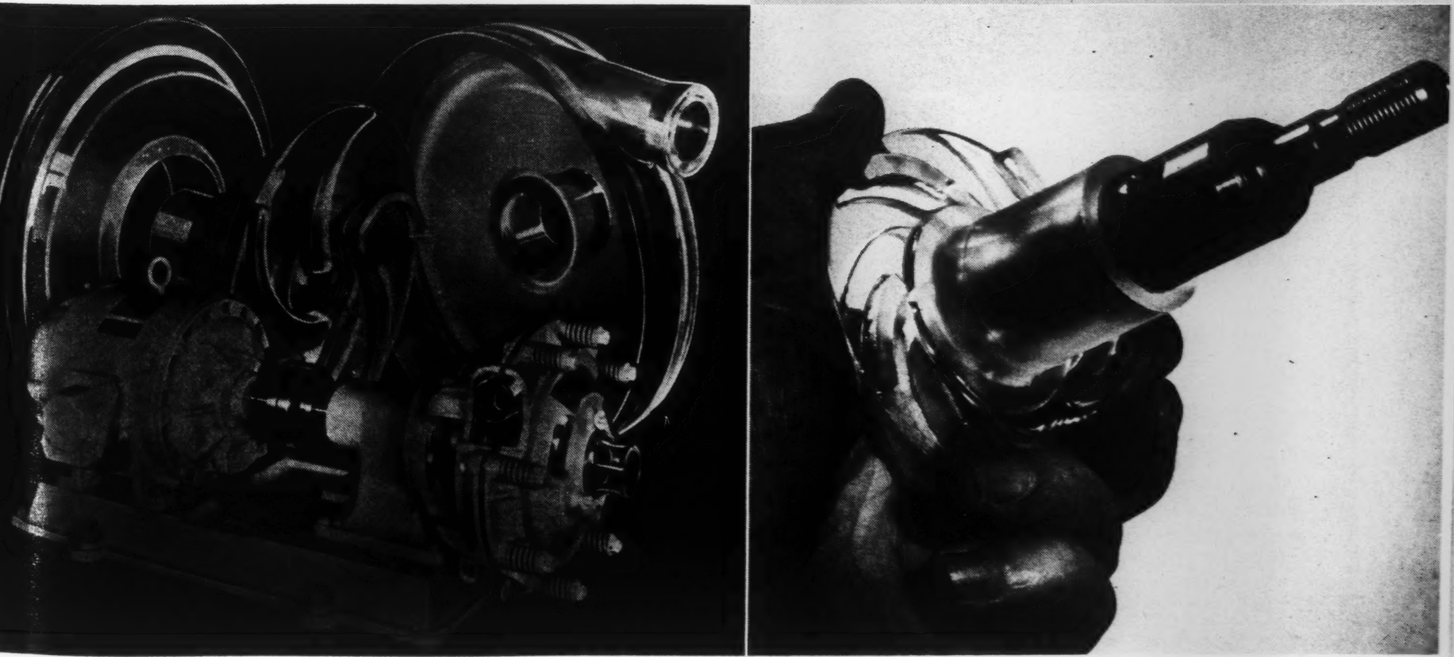


Fig. 1—Above—Mechanical strength possible in modern glass is here dramatically demonstrated

Fig. 2—Below—Mechanical strength, and resistance to corrosion and thermal shock characterize this all-glass pump. Steel drive shaft is locked into the hollow glass stub of the impeller assembly with a low-melting-temperature alloy



in the interior, increasing the mechanical strength of the article as much as 400 per cent.

Glass components can be sealed together easily and the resulting bond is as strong as any part of the glass. Mechanical clamps can also be used effectively to join glass and sections of other material, and assemblies of glass and metal parts may also be made by casting a lead alloy around the glass part.

Production of particularly intricate shapes or irregular contours is often accomplished by using the multiform process. Glass is ground into a fine powder and either dry-pressed or slip-cast into the desired shape. The finished pieces are fired to fuse the powdered particles into a homogeneous mass. Tolerances can be held to 0.005-inch in the multiform process.

Because of the wide range of composition, glass can also be produced which is easily sealed directly to metal parts, with or without an intermediate bond. Surfaces can be metallized for future soldering by spraying on metallic layers of brass or aluminum 0.001-inch thick or firing on coatings of silver or other noble metals. Bond strengths up to 2000 psi and vacuum-tight joints are possible.

Properties: Glass is particularly adaptable to manufacture of various mechanical parts because of the balance of several properties: thermal endurance, mechanical strength (*Fig.* 1), corrosion and abrasion resistance, dielectric strength, imperviousness, dimensional stability, smoothness, controlled transparency and low specific gravity.

The strength of glass cannot be measured in the same manner as that of metal or its hardness reported the same as for ductile materials. Glass is essentially a brittle material which has no plastic deformation before failure and which generally fractures from tensile stresses, not from pure compression. Ordinary working stresses of 1000 psi can be strengthened to as much as 4000 psi by tempering.

The most commonly thought of characteristic of glass—transparency—makes the material especially adaptable to several specific mechanical applications, although always in combination with other properties.

Chemical stability is a property which has a wide applicaton in mechanical parts, coupled with transparency. Glass is attacked by only four reagents: hydrofluoric acid, hot concentrated phosphoric acid, hot alkaline solutions and superheated water.

Applications: A typical mechanical part developed for corrosion resistance and visibility is the all-glass centrifugal pump, *Fig.* 2, produced by the

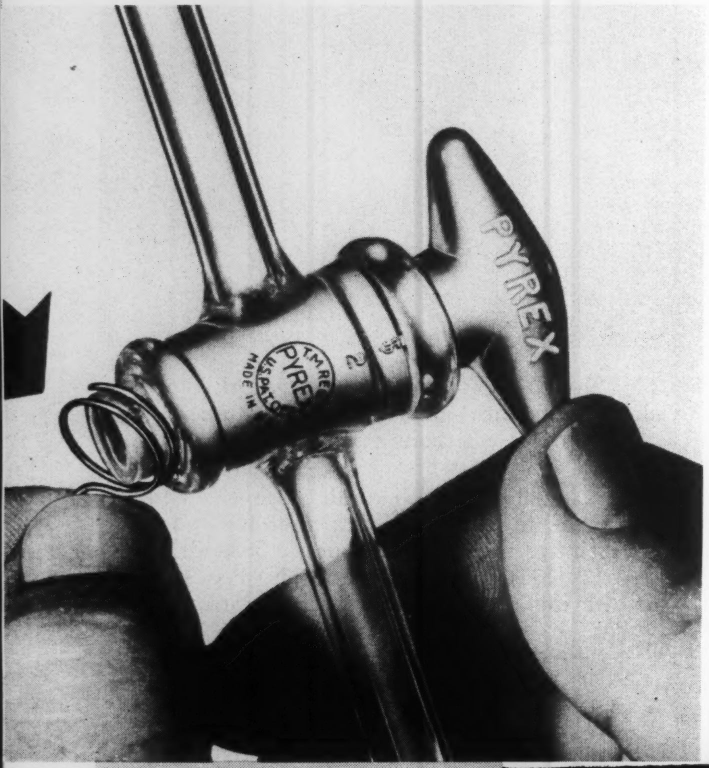


Fig. 3 — Above — Stopcocks have corrosion resistance and mechanical strength. The metal spring retains the plug and applies constant pressure between plug and shell

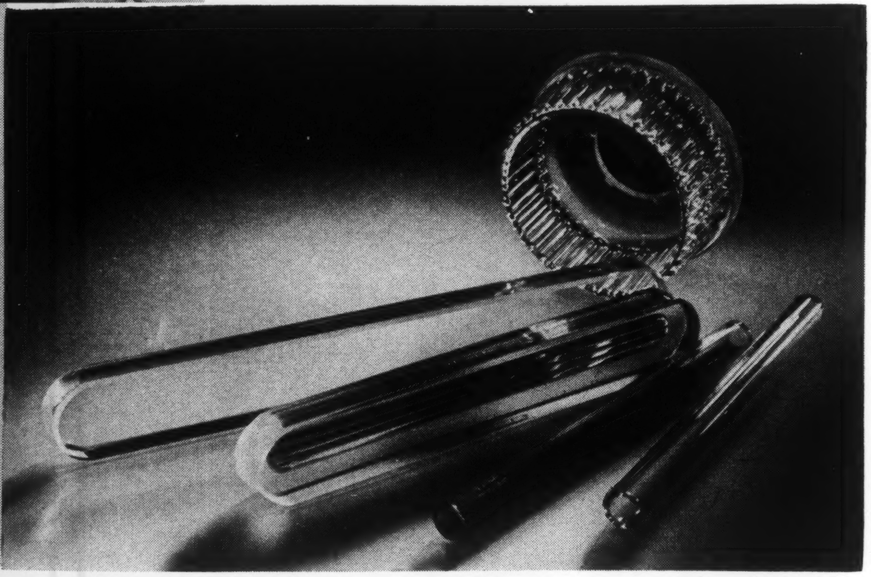


Fig. 4—Right—Godet wheel, used in the production of rayon, and gage glasses are fabricated to close tolerances

Nash Engineering Co. and Corning Glass Works. Glass parts include the head plate, impeller, volute and mechanical sealing ring. The pump is used widely in the chemical and food processing industries and is capable of handling 6000 gallons per minute against a 65-foot head while operating at speeds up to 3600 rpm.

Tolerances are held to ±0.002-inch between the impeller and the head plate and the smoothness of glass is vital in preventing accumulation of deposits. The ability of glass to withstand sudden temperature changes is equally important, as is the practicality of producing a glass-to-metal seal between the impeller and the drive quill.

Corrosion resistance is necessary in the manufacture of all-glass stopcock valves, *Fig.* 3, which are used with highly corrosive materials. The product is hand blown and individually lapped.

The precision-bore glass tube which is the heart of the variable flowmeter used by gas and chemical companies to measure the flow rate of liquids must also resist corrosion and provide maximum visibility. Tubing accurate to ±0.001-inch can be produced without further grinding or polishing. Dimensional stability, correct internal diameter, straightness and roundness are important factors.

Gage glasses, *Fig.* 4, must resist corrosion as well as withstand high pressures. Corning produces gage glasses as large as 13 inches long, $1\frac{1}{4}$ inches wide and $\frac{3}{4}$-inch thick, true to tolerances as close as ±0.002-inch. The glass is molded and then ground and polished, ready for insertion into a metal housing.

Chemical stability and smoothness are glass properties vital to the operation of godet wheels, *Fig.* 4, in the textile industry. The wheel is mounted on a spindle and functions as a roll guide to control the tension of rayon synthetic fibers being drawn from a hot acid bath after leaving the spinneret. The glass surface has a permanently smooth finish which precludes damage to the delicate fibers.

The godet wheel is manufactured in one molding operation and requires no additional polishing or plating. Since runouts must be held to close limits, tolerances are carefully controlled. A lead alloy bushing or hub is later cast to facilitate fitting a drive shaft.

The relative hardness of glass makes it adaptable to production of several mehanical parts. Glass hardness is not measured by the brinell or Rockwell machines, but is usually evaluated by scratch tests or impact-abrasion tests. On Mohs' scale of scratch hardness, glasses lie between apatite (5) and quartz (7). Glass is harder than mica, mild steel, copper, aluminum and marble.

Glass jewel bearings are produced for use in delicate electric instruments such as potentiometers. It is important that there be negligible friction loss and no abrasive particles to clog the instrument. Only sapphires have proven better than glass for this application.

Jewel bearings are manufactured from rods accurate to a tolerance of ±0.0235-inch. The one-step manufacturing process eliminates the need of abrasives in final polishing. Glass jewel bearings have exceptionally high surface hardness with high compressive strength.

Transparency and hardness are factors which make glass essential for photo printing cylinders. Cylinders are produced in sizes up to 59 inches long and $12\frac{3}{16}$ inches in diameter down to smaller units which must be held to extremely close tolerance for dry printing machines now used extensively in clerical work.

The rotary sealing ring used with the Nash centrifugal pump not only must resist corrosion, but must also have great dimensional stability. The multiform body of 96 per cent silica glass has uniform density and has such thermal resistance that it can survive the heat generated when the pump

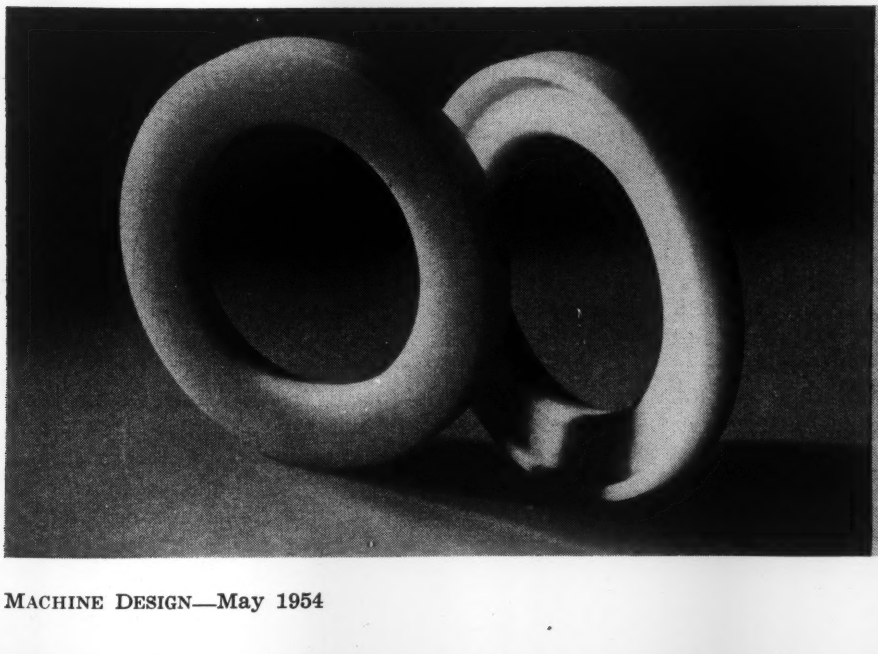


Fig. 5—Glass rotary sealing rings designed to withstand thermal shock and maintain dimensional stability

runs dry. The sealing ring can be manufactured to a tolerance of ±0.0005-inch. Typical rings are shown in *Fig.* 5.

Another application of glass in which resistance to abrasion is important is the slide valve disk used in gas meters. Glass permits proper union with a die-cast zinc land which makes the seal and does not deposit abrasive particles in the meter mechanism. Glass is the only material found practical for valves of this type.

The dielectric properties of glass are important in several mechanical applications. Glass is the only material practical for mercury switch envelopes. Not only is the glass resistant to electricity and to corrosion by mercury vapor, but it is of such a nature that vacuum seals can be made.

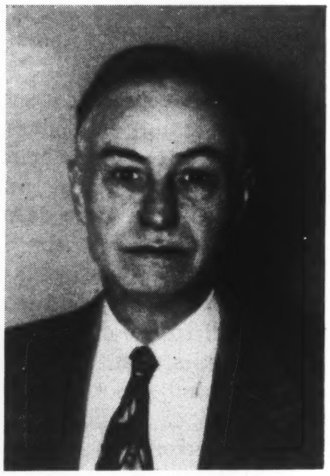
A newer product is the level switch used in aviation gyroscopes. Manufactured by the multiform process, the switch demands a surface flat to a close tolerance and must be adaptable to a glass-to-metal seal. The unit is sealed hermetically after insertion of an electrolite.

Development of new kinds of glass and new production methods are constantly increasing the scope of manufacture of mechanical glass parts. A radically new glass-forming machine is now in use for special production techniques and old methods are being improved.

It is now possible to machine intricate glass parts chemically using Corning's photosentitive glass. By an unusual chemical process, any design that can be photographed can be cut with extreme precision through part or all of the thickness of a piece of this new glass. Holes, lines, grids and more intricate patterns are readily cut without the aid of any mechanical cutting tool.

Finishing operations can be eliminated, and design situations simplified, by the use of . . .

PREFINISHED METALS



By C. P. Stewart *Works Manager*

American Nickeloid Co., Peru, Ill.

ENGINEERS and designers are always seeking better ways to improve their products, reduce costs, simplify production, and find better methods and materials. The use of prefinished metals has been of invaluable help in many everyday design situations, *Fig.* 1. The idea of prefinishing is not new. Since 1898 prefinished metals have been used for the production of many items that would be economically unsound to produce by any other method. Today, prefinished metals are being supplied in both sheets and coils with chrome, nickel, copper, and brass polished and lacquered finished on cold-rolled steel, brass, zinc, aluminum and copper—in gages from 0.006 to 0.062 inch and in widths from ⅛ to 36 inches, TABLE 1.

Production: Prefinished metals can be blanked, bent, formed, stamped, drawn, roll-formed and spot-welded. Tempers normal to the cold-rolled base metal are standard in the prefinished state. To assist in fabrication, protective films of pressure-sensitive paper or a vinyl type strip coating are applied, *Fig.* 2, minimizing the hazards of inplant handling.

In a great many instances, it is not necessary to change design, tools, or handling methods. However, it is preferable to consider prefinished metal in the design stage where allowances for contours, size, gage, radius and die design can best be made. Quite often substantial savings in finished costs can be effected, together with a simplification of inventory and complete control of production from the raw material state to the finished product under one roof. In addition to bright and satin finishes, prefinished metals afford the designer choice of pattern finishes of crimped designs, embossed patterns and striped finishes consisting of alternating stripes of bright and satin finish. Such patterns are quite difficult to produce on a finished article with any degree of uniformity and at a satisfactory cost.

In general, these materials have a tensile strength about 10 per cent greater and ductility about 10 per cent less than the uncoated base metal of the same gage and temper. Deep-drawn parts or parts where the ratio of draw to diameter is great are not very practical because of the stretch in the base metal and the extreme distortion of the surface. Products that require gas welding, arc welding or spinning are also impractical. In many instances, notching and bending are substituted for drawing with excellent results and at a savings in die cost.

Applications: Prefinished metals are used widely for decorative purposes, but also have great utility value. Preplated metals have found their way into

Table 1—Characteristics of Preplated Metals*

Metal and Properties (Plate/base)†	Heat Resistance		Corrosion Resistance			Spot Welding	Soldering	Stamping			Etching
	Cont. (F)	Interm. (F)	Salt air§	Outside§	Inside			Blank	Bend; Form	Draw	
Chrome/steel—Rigid; smooth; lustrous; nontarnishing	500	1000	P	F	G	G	G	G	G	G	G
Nickel/steel—Rigid; smooth; lustrous	500	500	P	F	G	G	G	G	G	G	G
Chrome/zinc—White base; flexible; nontarnishing	150	200	P	F	G	P‡	G	G	F	F	G
Nickel/zinc—White base; flexible	150	200	P	F	G	P‡	G	G	F	F	G
Chrome/brass—Nontarnishing; easily worked	300	400	F	G	G	F	G	G	G	G	E
Nickel/brass—Durable; easily worked; smooth	300	400	F	G	G	F	G	G	G	G	E
Chrome/copper—Nontarnishing; no season cracking; pliable	300	400	F	G	G	F	G	G	G	G	E
Nickel/copper—Pliable; no season cracking	300	400	F	G	G	F	G	G	G	G	E
Chrome/aluminum—Lightweight; white base; durable; nontarnishing	500	1000	F	F	G	F	G	G	F	F	G
Nickel/aluminum—Lightweight; white base; durable	500	500	F	F	G	F	G	G	F	F	G
Brass/steel; Copper/steel—Rigid; smooth; lustrous	175	200	P	F	G§	G**	G	G	G	G	F
Gold bond/steel—Resembles gold; stiff; smooth; lustrous	175	200	P	F	G§	G**	G	G	G	G	F
Brass/zinc; Copper/zinc—White base; flexible	150	175	F	F	G§	P	G	G	F	F	F
Gold bond/zinc—White base; flexible; resembles gold	150	175	F	F	G§	P	G	G	F	F	F
Tint metal/steel—Rich colors††; durable; workable	150	175	P	F	G	P	F	G	G	G	N
Tint metal/zinc—Rich color††; durable; workable	150	175	P	F	G	P	F	G	F	F	N

* E—excellent; G—good; F—fair; P—poor; N—not recommended. † Intermediate plating coats used in some combinations. § Lacquered surface recommended. ‡ Brittle welds. ** Not recommended if lacquered. †† Bright tint or dull tint in red, blue, green, yellow; dull in gray.

Fig. 1 — Preplated chrome on steel has applications in design situations calling for heat resistance, as in this Broil-Quik fryer

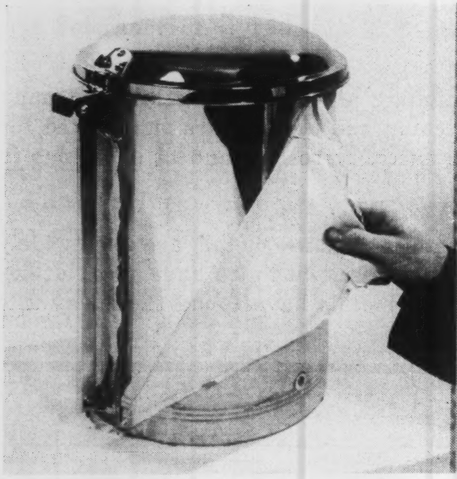
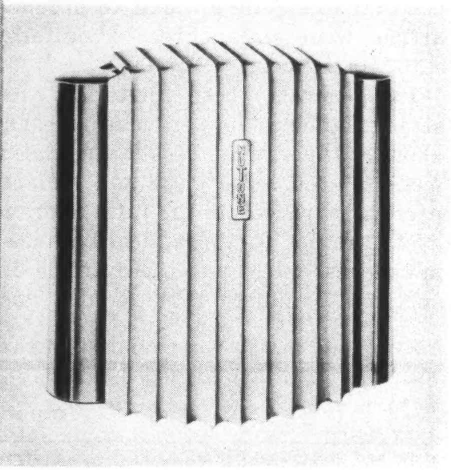


Fig. 2—Left—Flexible coatings over the prefinished metal protect against marring the finish during processing and handling

Fig. 3—Right—Brass or chrome-preplated tubes are combined with a fluted ivory or white cover on Nutone repeating door chimes



many fields, the more prominent of which are electrical appliances, housewares (*Fig.* 3), stoves and heaters, and lighting and lamps. Practically all manufacturers of broilers and rotisseries as well as deep fat fryers are using preplated chrome steel today. These are typical examples of products in which preplated metals promote decorative eye appeal and still retain utilitarian values. A list of just a few applications shows the wide range of utility: toasters, toys, nameplates, auto accessories, flashlight bodies, juke-box trim, pencil sharpeners, washing machine trim, switch plates, and control-knob inserts are all fabricated from these varsatile materials. Today, prefinishing is a sound practice, as evidenced by the increasing use of precoated metals for post-fabricated parts.

Besides its influence in beryllium copper, other unique properties and applications are provided by the element . . .

BERYLLIUM

By Gordon F. Simons
Technical Director

and Simon J. Morana *Research Chemist*

The Beryllium Corp., Reading, Pa.

ABOUT 20 years ago beryllium was considered a "wonder metal" with a promising industrial future as a lightweight construction material for aircraft parts. The metal is endowed with certain advantageous properties, TABLE 1, which spurred early interest in this field as well as in other potential industrial applications. It is practically as light as magnesium, has good corrosion resistance to water and air, and has a high strength to weight ratio along with a high modulus of elasticity, 40,000,000 psi. It has a melting point of 1285 C as compared with a melting point of 651 C for magnesium and 660 C for aluminum.

One of the outstanding properties of beryllium is its very great affinity for oxygen at elevated temperatures. For example, one gram of beryllium will absorb 1.774 grams of oxygen and liberate approximately 15.2 kilogram-calories in the combination. In its great affinity for oxygen at elevated temperatures metallic beryllium is similar to the present day "wonder metal" titanium, which is of great current interest as a metal possessing good strength to weight ratio and good corrosion resistance. The affinity for oxygen at elevated temperatures makes both of these metals a metallurgical problem in melting and processing. Titanium is very abundant in the earth's crust and the ore is readily available at a low cost. This, combined with the strong demand for a metal with titanium's properties, has spurred its metallurgy in an unparalleled manner for the defense program. Because of this concentrated research effort, many of the problems encountered in its melting and fabrication have been resolved in a remarkably short period of time.

Beryllium on the other hand is not considered one of the abundant elements, and there has never been any real sustained research directed toward developing more economical processes for its preparation and fabrication. Its main commercial source of supply is beryl, which is an accessory mineral in granite and pegmatite dikes. Although there are numerous deposits of beryl in the pegmatite areas throughout the world, the cost of mining brings the price of the ore to a high level. This, in turn, makes the price of the pure metal quite high, and has limited the use of pure metal only to a few special applications. Until recently, beryllium has been mainly used for the direct production of beryllium-containing alloys such as beryllium copper, beryllium aluminum, and beryllium nickel. More recent applications of pure beryllium in atomic energy projects have helped to create interest in the production of beryllium metal as such, and suitable techniques have been developed for its melting and fabrication.

There are two general processes for the preparation of metallic beryllium. One process involves the reduction of beryllium fluoride with magnesium to produce beryllium metal in fused form, generally in crude spheroids approximately one inch in diameter. This metal is known in the trade as beryllium "beads," and is produced both in a technical grade and a high purity grade. In the other process, beryllium chloride is melted with sodium chloride to form a fused electrolyte from which metallic beryllium is prepared in the form of dendrites, or "flakes," by electrolysis. The beryllium "flakes" produced by electrolysis generally contain less impurities than the fused "beads" produced by the fluoride process, and the individual dendrites appear to be somewhat ductile. In fact, some longer dendrites (one-half to one inch in length) can be twisted 360 degrees or more around their axis without breaking. Typical analyses of various grades of beryllium are presented in TABLE 2.

Chemical Properties: Pure beryllium is resistant to hot and cold water, although at elevated temperatures beryllium oxide is produced almost quantitatively according to the amount of water vapor introduced.

Although beryllium reacts with oxygen at temperatures as low as 300 C, it apparently is not directly reacted upon by molecular hydrogen at temperatures as high as 1100 C. Further, there is no severe corrosion of beryllium in air at 400 C in 200 hours.

Beryllium reacts slowly with nitrogen at 1000 C to form beryllium nitride, but the reaction rate proceeds much faster using ammonia to prepare the nitride.

Beryllium is resistant to concentrated nitric acid, but is readily attacked by hydrochloric and sulphuric acid in all concentrations. It reacts with

Table 1—Physical Properties of Beryllium

Density (gm/cc)*	1.846–1.816
Hardness, Brinell	97–172
Ultimate strength (psi)**	35,000–95,000
Yield strength, annealed, 0.2% offset (psi)	30,000–45,000
Elongation in 2-in. (%)	2–20
Reduction of area (%)	2–20
Modulus of elasticity (psi)	$36–44 \times 10^6$
Shearing strength (psi)	31,000–66,000
Electrical conductivity (% of Cu)	40–44
Electrical resistivity (microhms/cc)	3.9–4.3
Electrode potential (volts)	—1.69
Melting point (C)	1285
(F)	2345
Boiling point (C)	2970
(F)	5378
Linear coefficient of expansion (per deg C)	
20–200 C	13.3×10^{-6}
20–700 C	17.8×10^{-6}
Thermal conductivity at 20 C (cal/sq cm/cm/sec/deg C)	0.385
(% of Cu)	42
Specific heat, at 20–100 C (cal/gm/deg C)	0.43–0.52
Latent heat of fusion (cal/gm)	250–277
Vapor pressure (mm Hg)	
1400 C	0.001
3000 C	760.0
Heat of oxidation (cal)	140.15
Magnetic susceptibility (gauss/oersted c.g.s.)	0.79

* Theoretical density reported by two different sources.

** Tensile properties may vary over a wide range, according to the method of fabrication employed.

Source: Reference 1; see end of article.

Table 2—Typical Analyses of Various Beryllium Grades

Element	Tech. Grade Beads	High Purity Beads	Vacuum Melted Beads (Ref. 2)	High Purity Flakes
Al	0.50%	0.05%	0.080%	0.005%
Fe	0.45	0.10	0.085	0.015
Mn	0.13	0.01	0.024	0.001
Ni	0.01	0.01	0.014	0.030
Cu	0.50	0.05	0.005	0.010
Mg	1.20	1.20	0.005	0.003
Si	0.05	0.05	0.075	0.010
Ca	0.01	0.01	0.009	n.d.
Cr	0.18	0.02	0.013	n.d.

concentrated alkalies and with warm dilute alkalies, but is not attacked by ammonium hydroxide.

Chemically, beryllium is quite closely related to aluminum, and its complete separation from this element is difficult.

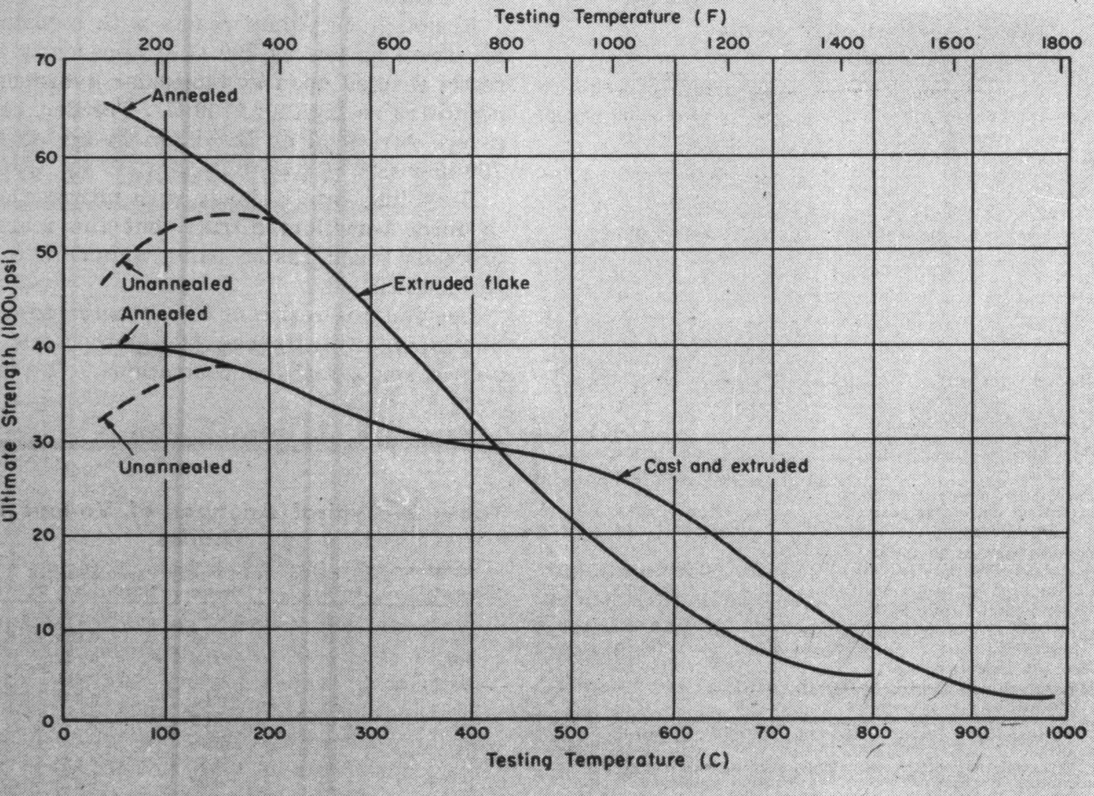
Fabrication and Uses: Both beryllium beads and beryllium flakes can be compacted by melting, and can be cast into shapes by using special techniques that have been developed for its handling. Metallic beryllium has a relatively high melting point and is extremely reactive chemically, especially with respect to oxygen and carbon. This poses a problem for the selection of a satisfactory crucible material for melting, and the only material found that does not give a serious impurity pickup is beryllium oxide. Beryllium reacts exothermally with carbon at temperatures even below its melting point to form beryllium carbide, and for this reason graphite cannot be used as a melting crucible. However, a graphite crucible lined on the inside with beryllium oxide is satisfactory for melting beryllium in an induction furnace. By using a vacuum in melting beryllium, oxidation losses are reduced and certain volatile impurities are removed.

Beryllium powder is produced from both bead and flake metal. By adapting conventional powder metallurgy techniques it should be possible to prepare various shapes of beryllium metal by cold compacting, followed by vacuum sintering. Also, by mixing beryllium powder with other metal powders it is possible to prepare beryllium alloy compacts of varying composition.

Although beryllium as high as 99.97 per cent purity (oxygen unknown) has been reported in the literature, the metal has invariably been reported to be brittle. This indicates that the brittleness probably is not associated with the ordinary metallic impurities. Kaufmann and others have carried out an intensive study of beryllium metallurgy in an effort to find out whether or not beryllium can be made ductile.[3] The effect of various impurities on physical properties, microstructure, lattice parameter, and electrical resistivity were examined, but no explanation of the brittleness was found. It was shown that out of 35 alloying elements investigated, only copper, palladium, cobalt, nickel, and silver have appreciable solids solubility in beryllium.

The ductility of beryllium increases rapidly above room temperature, the two temperatures of maximum ductility in tension being 400 C and 800 C. In contrast to the powder metallurgy products and to cast products, extruded beryllium shows

Fig. 1—Ultimate strength versus temperature of extruded beryllium



directional differences in tensile properties. Extruded beryllium can exhibit an elongation in tension of 5 to 10 per cent in the direction of extrusion, but the elongation is substantially zero in a perpendicular direction.

Forging and rolling of cast beryllium either hot or cold lead to almost immediate cracking when using ordinary metallurgical techniques. However, the rolling of beryllium is possible at any temperature between 370 and 1095 C if the beryllium is encased in some other suitable metal. The best results are obtained if the beryllium has been previously forged or extruded.

The best way to produce beryllium bar stock or tubing is through extrusions. Special techniques are used involving enclosing the cast billet in a steel jacket, and extruding at temperatures between 815 and 1095 C through conical dies. Flake and powder beryllium may also be converted to solid metal by cold compacting inside an iron can, welding on an end plate, and then extruding as with cast metal at 980 to 1040 C. It is possible to hot extrude beryllium into bars, tubes, ribbons, hexagons, etc. Ultimate tensile strengths of extruded shapes are shown in *Fig.* 1.

Beryllium lends itself readily to normal machine shop practices such as lathe and shaping work with the use of carbide cutting tools. It can be cut on a band saw with a standard stock blade. Wrought beryllium machines much easier than cast beryllium due to the large grain size normally present in the cast metal.

The forging characteristics of wrought beryllium are similar to those of magnesium. It forges well at 400 C in closed dies. Graphited oils or grease are suitable lubricants.

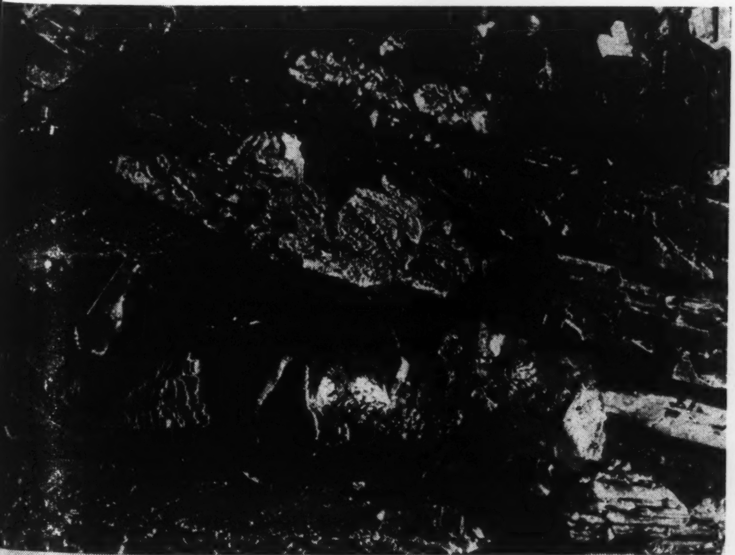


Fig. 2—Typical beryllium dendrites or flakes produced by electrolysis, magnified 50 times

Beryllium can be welded to itself and to aluminum without filler rods, using straight polarity, helium-shielded arcs.

Beryllium is one of the most effective of all materials for slowing down neutrons and, in addition, it has litle tendency to absorb them. Beryllium is also important as a source of neutrons, which are formed when it is bombarded with alpha particles. For these reasons, beryllium has been proposed and has a great potential value for atomic energy purposes as a moderating material for thermal-energy nuclear reactors. It is also of interest as a reflecting material for nuclear reactors, as an alloying agent, and as a cladding material for fuel elements. Widespread use of beryllium in the moderator is conditioned by the relatively high price of reactor grade material.

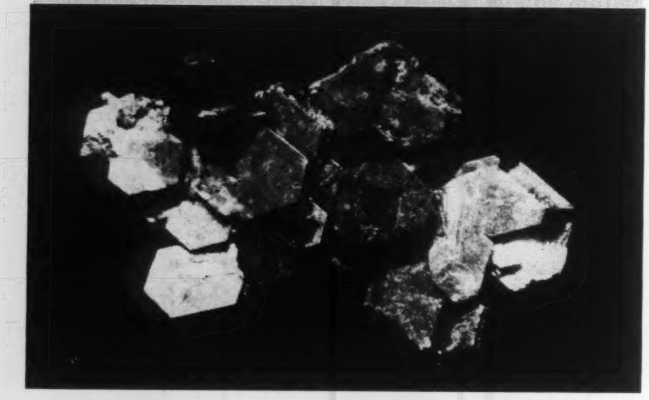
It is quite probable that continued research on beryllium alloyed with other metals having low thermal neutron absorption cross-sections will result in several useful alloys with significant improvements in mechanical properties.[4] For example, further investigations are presently underway to prepare and evaluate combinations such as beryllium-magnesium, beryllium-aluminum, beryllium-zirconium, beryllium-aluminum-zirconium, etc.

Metal-ceramics, or cermets, are becoming increasingly important in the manufacture of jet engine components, rocket nozzles, burner cones for gas turbine combustion chambers, thermocouple protection tubes, and similar items where resistance to elevated temperatures and improved thermal shock over ceramic materials are requisites.

The use of beryllium in beryllium-beryllium carbide cermet bodies has been investigated by using cold pressing and sintering methods, and hot pressing methods.[5] The modulus of rupture values at room temperature for hot pressed material containing 35 per cent beryllium and 65 per cent beryllium carbide by weight average 35,000 psi and a compressive strength of 92,000 psi is obtained. The value of 35,000 psi exceeds the average modulus of rupture value of beryllium carbide by a factor of two. Cermets of beryllium-beryllium oxide have also been investigated. The modulus of rupture of 28 per cent beryllium and 70 per cent beryllium oxide is approximately 35,000 psi and the compressive strength is 80,000 psi.

Beryllium has a high permeability to X-rays owing to its low atomic weight. This property, combined with its strength and high melting point, makes it ideally suited for windows in X-ray tubes, and has made the use of longer wave X-rays possible for such applications as X-ray therapy and the X-ray study of light metals. Its permeability is approximately 17 times greater than that of aluminum, which was the metal previously used for this application.

Fig. 3—Beryllium dendrite, magnified 100 times, showing the hexagonal structure commonly found



Technical grade beryllium beads are presently being quoted at $71.50 per pound, and high purity electrolytic flake at $90.00 per pound by the Beryllium Corp. Typical beryllium dendrites or flakes produced by electrolysis are shown in *Fig.* 2. *Fig.* 3 shows a dendrite, illustrating the hexagonal structure commonly found in the beryllium dendrites.

Beryllium is used in small amounts to reduce the oxidation of magnesium and magnesium alloys during melting and casting, and to increase corrosion resistance. In aluminum-base alloys 0.005 per cent beryllium restrains oxidation in the molten state and refines the grain. For these applications beryllium is added in the form of a 5 per cent beryllium and 95 per cent aluminum master alloy.

Future main uses for beryllium will probably continue to be in the field of alloys and as small additions to other metals. The rapidly developing use of atomic energy will very likely expand the use of pure beryllium metal for special applications not even considered at present.

Recent experience with beryllium and beryllium compounds has shown that some of these materials may be toxic. However, authorities seem to be in disagreement as to the exact nature of the cause of the toxicity commonly associated with beryllium and beryllium compounds. Safety precautions presently believed to be necessary for the handling of these materials should be followed by anyone working with beryllium.

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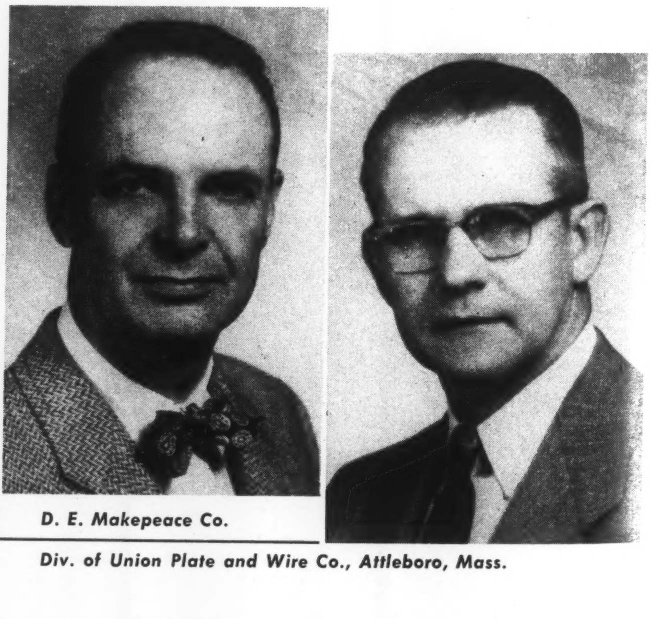
Desirable electrical properties and corrosion resistance of precious metals can be obtained economically by using . . .

PRECIOUS-METAL LAMINATES



By W. Channing and G. H. Barney

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ORIGINALLY used over 100 years ago as much-prized Sheffield plate, silver and other precious metals laminated to base metals are now part of everyday life in such varied objects as the contacts through which a phone call travels, the gadget which turns on the refrigerator, or the newest type of carbide-tipped tool, *Fig.* 1. Perhaps the best known present-day use for precious metals in industry has been for electrical contacts. Here the various types of laminated strip are coming into widespread use because of characteristics which are difficult and often impossible to duplicate in other types of individually attached contacts such as rivets or brazed tips. But other applications, such as use for chemically resistant parts, waveguide tubing, and other electronic uses, are also important, and new applications are being developed daily.

Basic Laminate Construction: In the manufacture of laminated strip a precious metal, such as silver, gold or palladium, is bonded to a base metal, such as brass, copper, phosphor bronze or beryllium copper, through the application of heat and pressure in specially constructed furnaces. The bond between the two metals, achieved by a type of welding action, is strong enough to permit the composite laminated strip to undergo severe forming, deep drawing or brazing operations without affecting the bond. Fracture of the solid metal often occurs before the bond is broken. After the two metals are bonded, the laminate is cold-rolled to any degree of hardness in thicknesses down to 0.002-inch or even thinner. A cladding of precious metal on one or both surfaces of a few tenths of a thousandth up to a quarter inch or more is maintained uniformly over the surface of the base metal. Laminated metals can thus combine in one strip the useful properties of two or even three metals, *Fig.* 2. For instance, the spring properties of

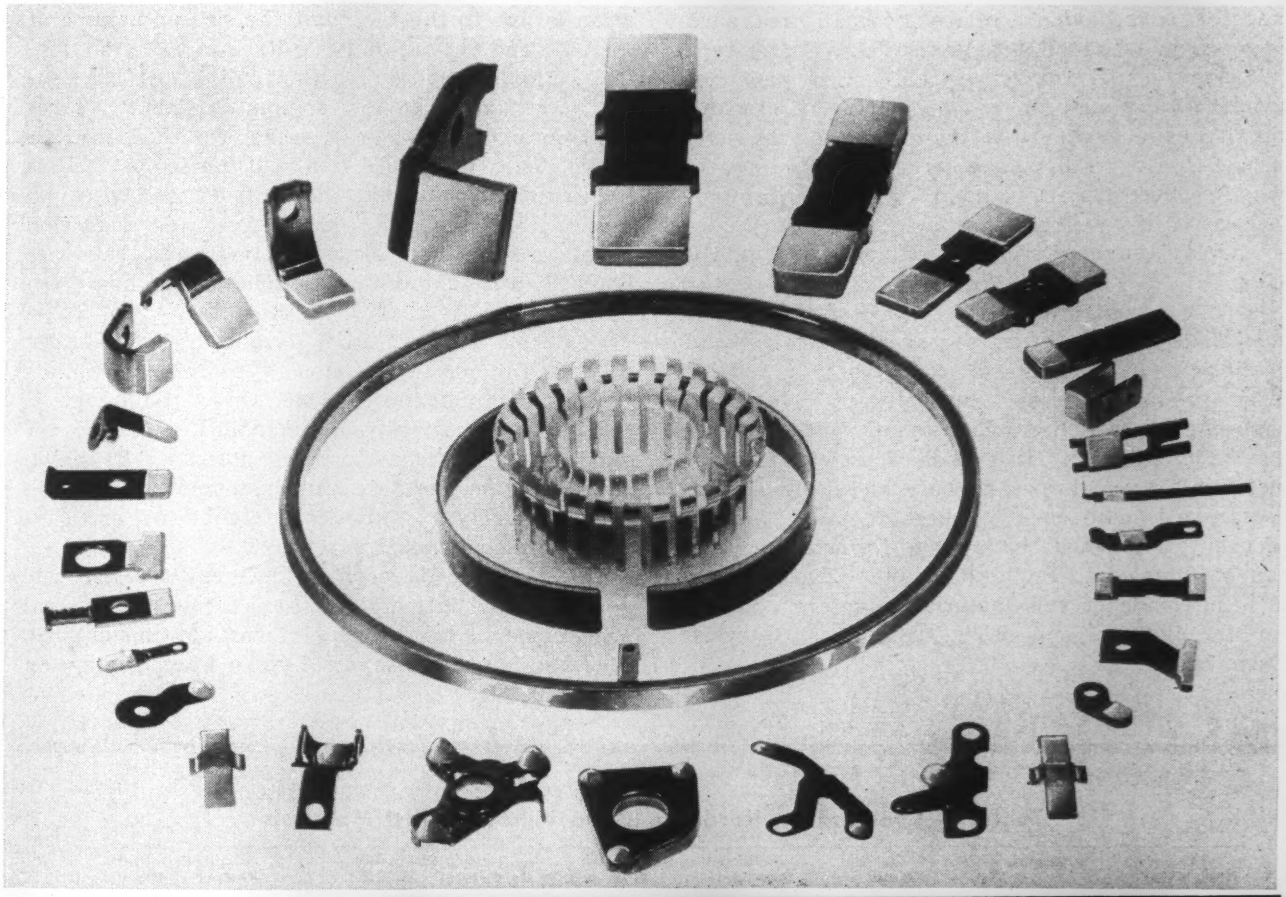


Fig. 1—Above—Contacts and collector rings made of laminated precious metals

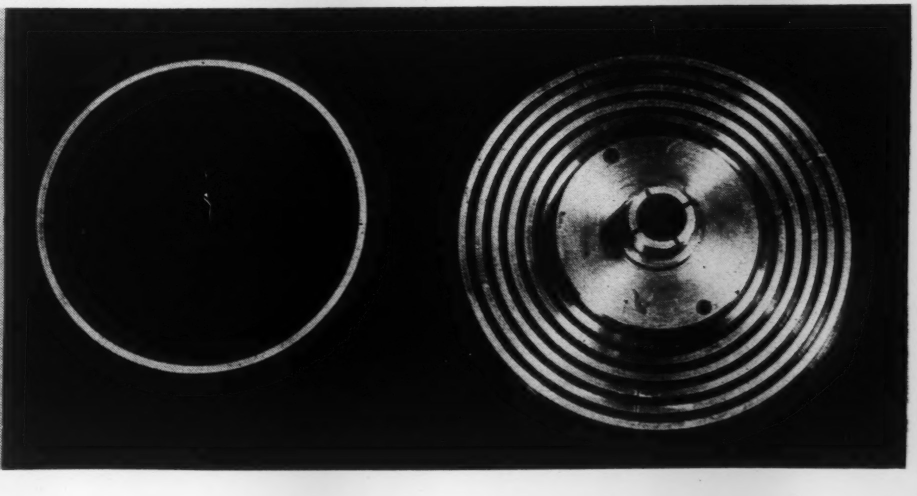


Fig. 2 — Right — A gold-platinum alloy laminated to brass provides the optimum combination of properties for slip rings used in a molded assembly

phosphor bronze can be utilized together with the conductivity and contact life of coin silver in silver-clad springs; the strength and economy of hard brass with the characteristics of fine silver; the heat-treatable properties of beryllium copper with the corrosion resistance of a gold alloy. Laminated strip is blanked out and formed into finished parts, often with no further operations necessary.

Types of Laminates: To insure that precious-metal scrap is kept to a minimum and to fit the needs for heavy and light loads and pressures, several varieties of laminated strip have been developed, *Fig.* 3.

Overlay laminates with the precious metal on one or both surfaces are used for lightweight parts or parts having a relatively small area, such as the kidney-shaped springs used in a turret type TV tuner, made from silver-clad spring phosphor bronze. Inlay strip, in which an inlay of precious metal covers only part of the surface of the strip is used for parts having a larger area or greater weight, where a precious metal over the entire surface is not necessary or economical. A third type is edgelay, having thicker precious metal on the edge.

A newly patented strip—called Spotlay—has been developed to secure the greatest economy of precious metals. This material is best suited for large production runs, especially of irregularly shaped parts which would normally yield a large proportion of scrap. It is made of spots of precious metal inlaid and brazed in base metal strip. The spots are located exactly where required for contacts in the finished blanked and formed piece, and can be dimpled to required height. Excellent use is being made of this material in rotary contacts for the ignition and other switches in Chrysler Corp. cars.

Strip with a raised layer of precious metal (Raisedlay) has found increasing application as an improvement over brazed-tip contacts. TABLE 1 shows the comparative hardness achieved in these types of parts. Contact life and economy in silver can thus be greatly improved.

Actual hardness values of Raisedlay contact materials are listed in TABLE 1 against approximate values of the same materials in the soft or brazed condition. Although the values themselves may in places appear confusing, inasmuch as similar materials rolled to approximately the same temper may vary in hardness, it should be noted that the hardness of both the silver contact and base material is always greater than that of the same materials in the brazed condition. This hardness variation is due to the fact that the size and shape of each Raisedlay material results in a different material flow when confined during the final hardening operation. The last column in TABLE 1 gives the approximate hardness values for the base materials when flat rolled to the listed temper. It is interesting to note that the confined method of reducing Raisedlay, an equal percentage reduction usually results in a considerably greater hardness value than is achieved in the usual flat rolling process.

Crossbar contact tape, developed by Western Electric for use in telephone type relays, is made from palladium-capped nickel wire. This tape is fed into automatic welding machines which cut off and attach segments to relay springs. By using crossbar type contacts, misalignment problems in relay assembly are practically eliminated, and saving of precious metal is achieved.

Designed for an entirely different type of use, solder-flushed trimetal strip has found universal acceptance in the brazing of carbide-tipped tools. Made by bonding a layer of silver brazing alloy on

Table 1—Comparative Hardness (Rockwell) of Contact Materials

Materials			Raisedlay Strip		Brazed Contacts		Rolled Sheet	
Base Metal	Tips	Temper (% red)	Base Metal (No., scale)	Tips (No., scale)	Base Metal (No., scale)	Tips (No., scale)	Temper	Base Metal (No., scale)
Copper	Fine silver	20	51, 30-T 79, 15-T	56, 30-T 81, 15-T	40, F	32, 15-T	½-hard	44, 30-T 74, 15-T
Copper	Fine silver	20.4	42, B 81, F	78, F 72, 15-T	40, F 40, F	32, 15-T	½-hard	44, 30-T 74, 15-T
95-5 brass	Coin silver	8.6	82, F 50, 30-T	82, 15-T 61, 30-T	45, F	74, 15-T 42, 30-T	¼-hard	71, 15-T 37, 30-T
90-10 brass	Fine silver	9.0	84, F 47, 30-T	77, F 45, 30-T	48, F	32, 15-T	¼-hard	74, 15-T 43, 30-T
90-10 brass	Fine silver	20.4	62, B 92, F	35, B 79, F	48, F	32, 15-T	½-hard	58, B
90-10 brass	Fine silver	10.5	60, B 88, F	25, B 74, F	48, F	32, 15-T	¼-hard	78, 15-T 51, 30-T
65-35 brass	Fine silver	9.8	76, 15-T 44, 30-T	75, 15-T 44, 30-T	64, 15-T 22, 30-T	32, 15-T	¼-hard	78, 15-T 51, 30-T
65-35 brass	Fine silver	21.6	71, B 98, F	52, 30-T 85, F	10, B 22, 30-T	32, 15-T	½-hard	69, B 63, 30-T
Gr. A phosphor bronze	Fine silver	11.4	69, B 96, F	44, 30-T 79, F	29, B 36, 30-T	32, 15-T	¼-hard	60, B 57, 30-T
Gr. A phosphor bronze	Fine silver	21.8	84, B 105, F	48, 30-T 80, F	29, B 36, 30-T	32, 15-T	½-hard	74, B 66, 30-T
Gr. A phosphor bronze	Fine silver	33.3	89, B 107, F	48, 30-T 82, F	29, B 36, 30-T	32, 15-T	Hard	88, B 75, 30-T

each side of a layer of base metal at exactly the optimum thickness for tip brazing, this strip, blanked into appropriate shims, provides a shock-resistant cushion for the carbide tip. In most rugged machining jobs where the brittle carbide is subject to fracture, it has been found that a shim of copper or nickel between the tip and toolholder prevents breakage. Thus a new type of laminated metal, which has potential uses for other than tip brazing, was developed.

Several other forms of precious-metal laminates also find major application. For instance, laminated tubing, with a hard-drawn layer of precious metal on the inside, outside or both sides, is made by a deep-drawing process from laminated sheet. This tubing answers the need for rotary contacts in the form of slip rings, and silver-lined coaxial and waveguide tubing. In chemical processing, precious metal-clad tubing provides corrosion resistance without the expense of solid precious metals. Clad wire, another type having a hard jacket of precious metal, is used to make instrument brushes, RF coils, and in certain special applications.

It is almost impossible to cover all the applications in which laminated precious metals have been used. Brand-new ones are constantly being found in many fields, in a wide variety of equipment.

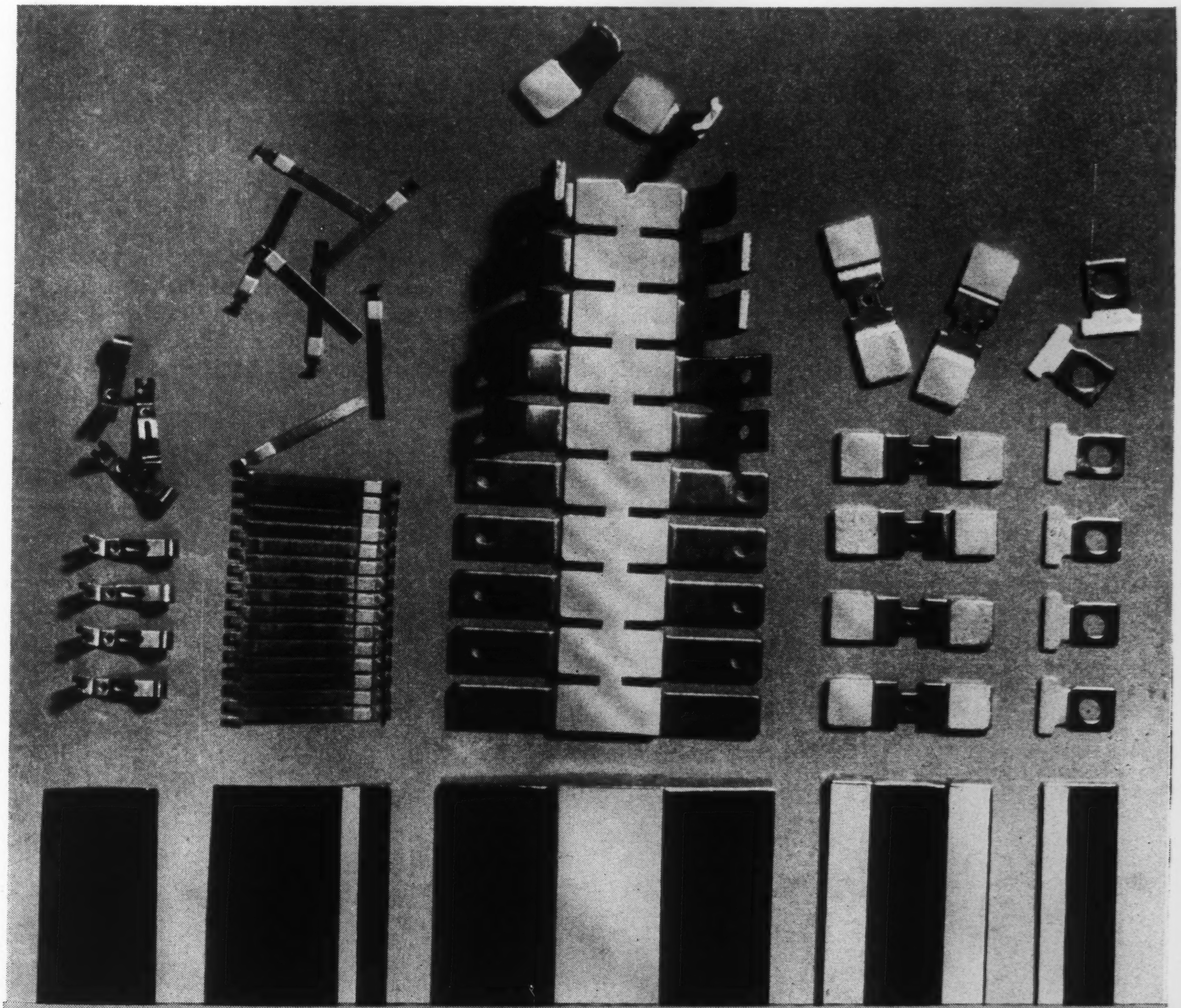


Fig. 3—Typical precious-laminate parts, and strip from which they are made. From left to right, the parts are: springs, coin silver on phosphor bronze; contacts made from Raisedlay material; contacts, silver on beryllium copper Raisedlay; bridge type contacts, silver on phosphor bronze; and contacts made from inlay material

During the past year, several new materials of striking interest have been added to the family of . . .

SILICONES

By T. A. Kauppi *Manager, Product Engineering*

Dow Corning Corp., Midland, Mich.

SILICONES—the family of unique materials which combine the properties of organic and inorganic materials—have gained a number of new compositions over the past year or so. Silicones have already proved their value in many areas of use; the new silicone materials further extend these areas for designers.

Silicone resins, for example, are currently being widely employed as high-temperature dielectrics in the form of silicone and glass cloth laminates, tapes, and similar materials, *Fig.* 1. They have made possible a new class of insulation—class H—rated to withstand hot-spot temperatures of 180 C. In protective finishes, silicone resins span the heat-resistance "gap" between conventional organic resin finishes and the inorganic, porcelain or ceramic finishes, *Fig.* 2. Silicone rubbers are being used for resilient parts operating in extreme temperature ranges of −100 to 500 F, *Fig.* 3. Silicone oils and greases are often specified for extreme temperature

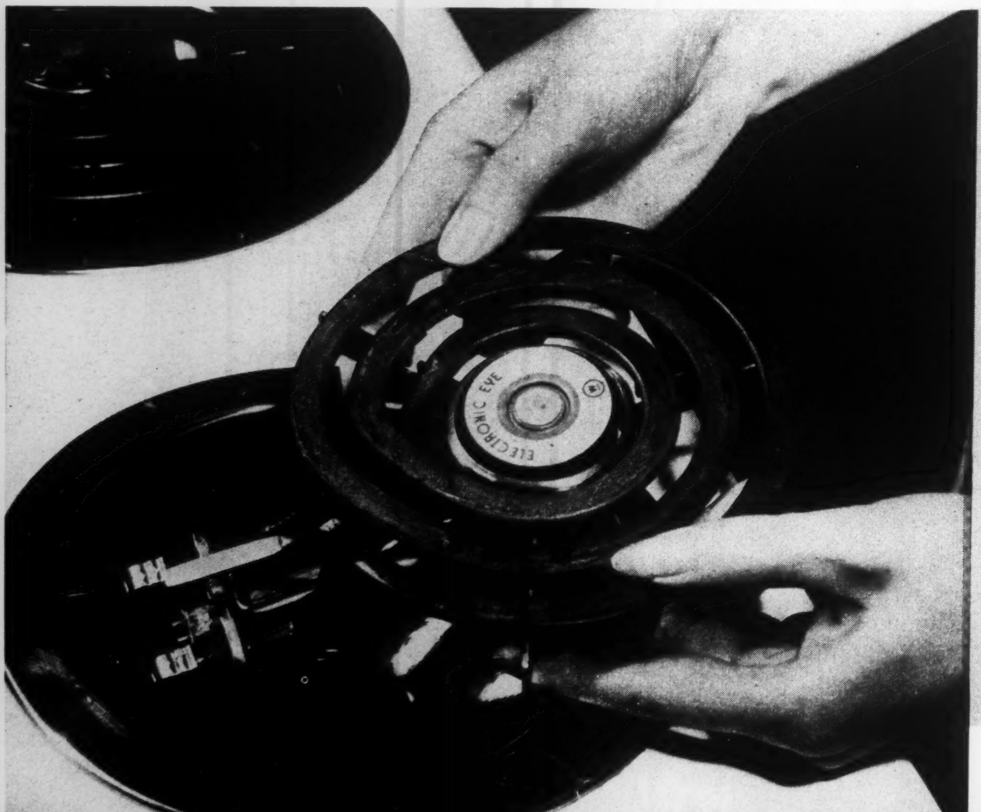


Fig. 1 — Silicones are used for high-temperature insulation and resistance to boiling water, grease and foods on this Electronic Eye surface unit on the Westinghouse range. A Thermistor imbedded in silicone paste turns current on and off automatically. A flexible Silastic diaphragm protects the Electronic Eye, and silicone-insulated cable connects the thermistor to exterior wiring

ranges. And silicone fluids, because of their relatively flat viscosity-temperature curves, have been found to be ideal damping media for instruments, dashpots and heavy-duty vibration dampers.

These are applications in which silicones have already proved themselves. But among the new materials introduced during the past year are several silicone products of major importance to design engineers. Like all true silicone products, these new materials are serviceable at temperatures above and below the usual limits for organic materials. They range in physical form from pressure-sensitive adhesives to rubbery solids that vulcanize at room temperatures. Some of the more significant properties of these new silicone products are summarized in this article.

Pressure-sensitive silicone adhesives are now used in the commercial production of tapes that maintain high adhesive strength at temperatures from −67 to 500 F in contact with a wide variety of surfaces, including most metals, paper, plastics, glass and silicone-glass laminates. Such tapes have a wide field of potential usefulness as electrical insulating tapes, and as mounting or packaging tapes that are weather-resistant and serviceable at both high and low temperatures.

A new silicone bonding resin designed for use in the low-pressure fabrication of silicone-glass laminates cures more rapidly than other silicone resins and imparts greater mechanical strength both at room and at elevated temperatures. For example, ⅛-inch laminates of 181 glass cloth bonded with Dow Corning 2106 have a flexural strength of 50,000 psi at room temperature. At 500 F, flexural strength is 12,000 to 15,000 psi for laminates cured 6 to 12 hours at 500 F. Flexural strength at 500 F goes up to 18,000 to 24,000 psi in laminates cured for 48 hours at 500 F.

Another new silicone bonding resin makes possible the production of silicone-glass laminates with over 100 times the dielectric life at 250 C obtainable in the best of the silicone-glass laminates previously available. Typical ⅛-inch samples of Dow Corning 2105 bonded glass cloth laminates with an initial dielectric strength of 300 volts per mil retain a dielectric strength of 180 volts per mil after aging for 5000 hours at 250 C.

Two expansible silicone resins have been developed for the production of rigid cellular structures that are nonflammable and remarkably heat-stable with a heat distortion temperature above 700 F. Either of these resins can be expanded to a density of 6 to 24 pounds per cubic foot. They can be

Fig. 2—Aluminum-pigmented silicone enamel (Sicon Aluminum) is used on this cover casting and steel bracket to provide protection at high temperatures. Temperatures too high for conventional organic finishes are resisted successfully on the aluminum alloy cover casting; the silicone-aluminum finish replaces cadmium plating on the bracket to reduce the possibility of alloying at high temperatures

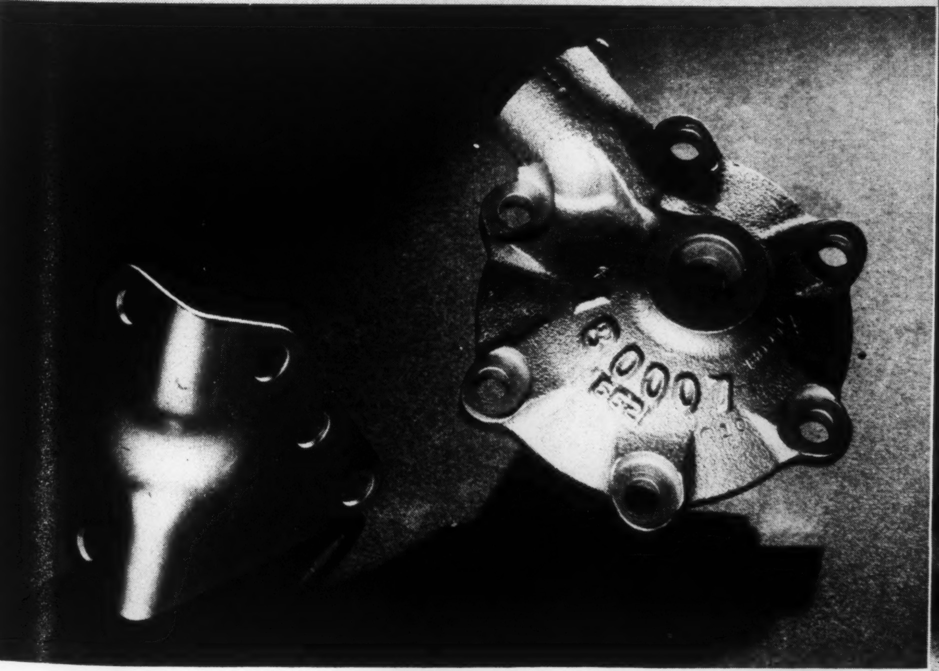
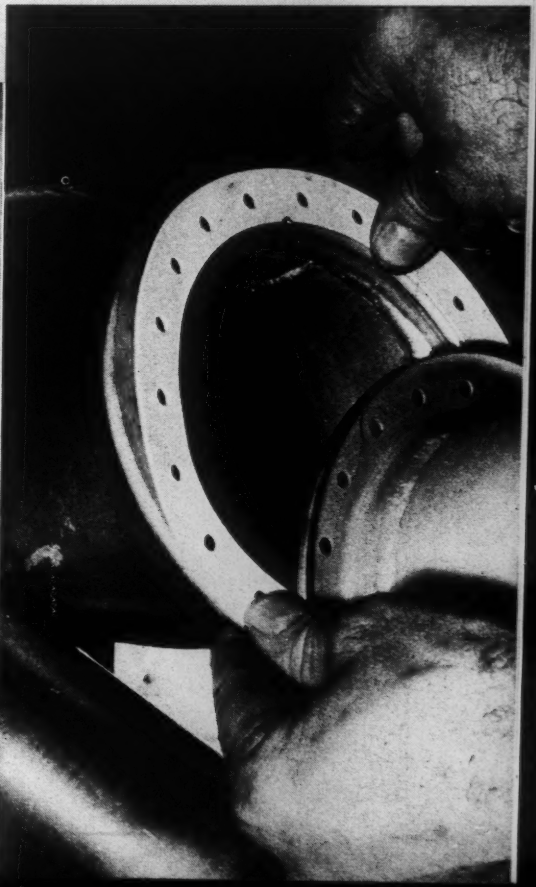


Fig. 3—Silicone rubber gaskets in aircraft cabin heating and pressurizing systems must stay elastic at temperatures from −70 to 400 F

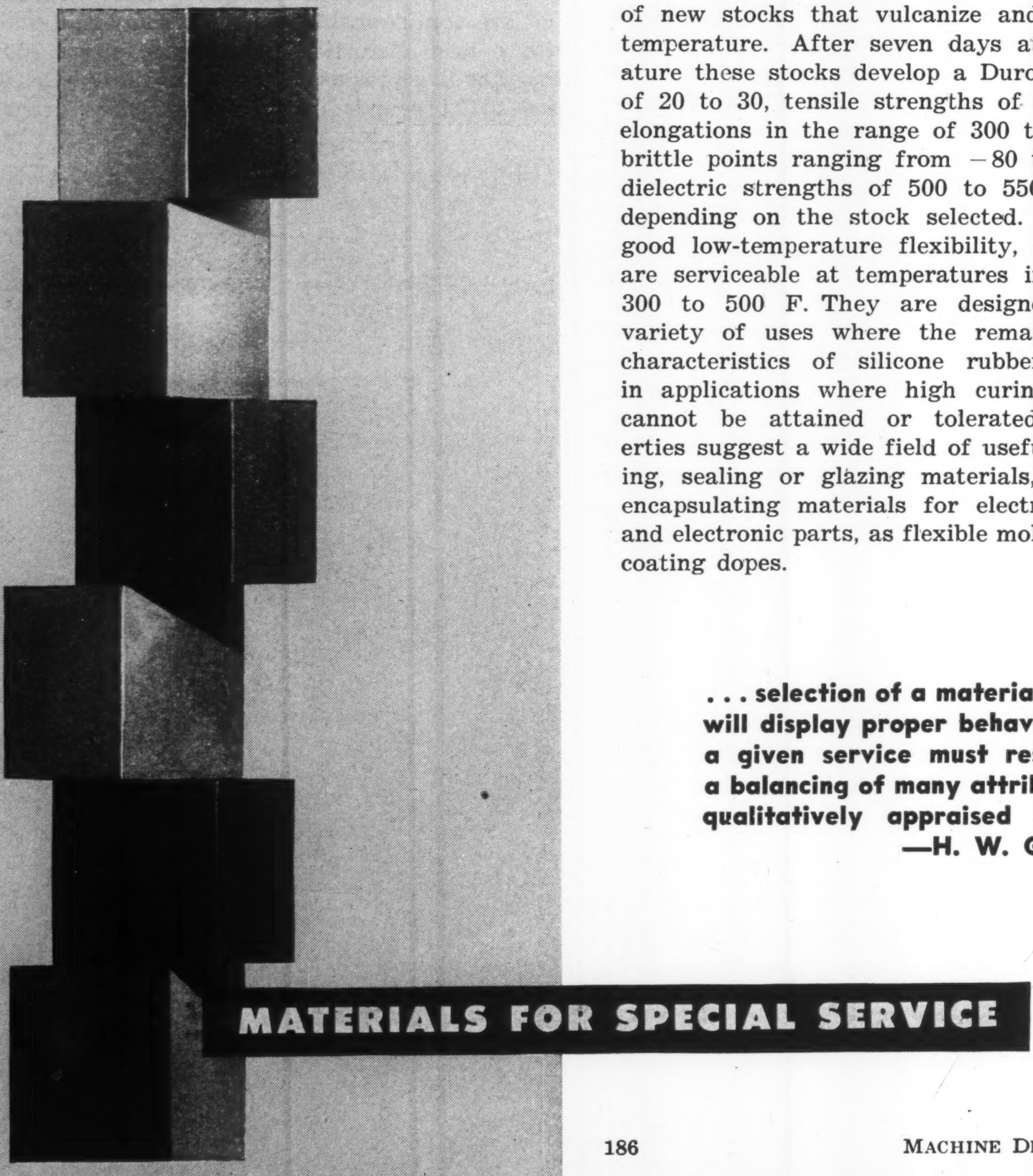


foamed in place, made up as a sandwich construction or produced in various shapes and machined with conventional woodworking tools. Properties of these foamed resins suggest their potential usefulness as fire walls and as thermal or electrical insulating bodies.

New among silicone rubbers is a stock in which low shrinkage and high resistance to permanent compression set are combined with serviceability at temperatures ranging from −100 to +500 F. Typical samples molded of this Silastic stock show a shrinkage of less than 2.5 per cent after 1000 hours at 390 F, and less than 7 per cent after 1000 hours at 480 F. Compression set after 22 hours under load at 300 F is in the range of 15 to 20 per cent. After 70 hours at 300 F, compression set is still only 20 to 28 per cent. And, unlike many silicone rubbers compounded for low compression set, this Silastic stock contains no toxic ingredients. It can therefore be used as a gasketing or sealing material in contact with cosmetics, foods or pharmaceuticals.

Most unusual among silicone rubbers is a series of new stocks that vulcanize and cure at room temperature. After seven days at room temperature these stocks develop a Durometer hardness of 20 to 30, tensile strengths of 185 to 325 psi, elongations in the range of 300 to 400 per cent, brittle points ranging from −80 to −110 F, and dielectric strengths of 500 to 550 volts per mil depending on the stock selected. In addition to good low-temperature flexibility, these materials are serviceable at temperatures in the range of 300 to 500 F. They are designed for a wide variety of uses where the remarkable stability characteristics of silicone rubber are required in applications where high curing temperatures cannot be attained or tolerated. Their properties suggest a wide field of usefulness as caulking, sealing or glazing materials, as potting or encapsulating materials for electrical assemblies and electronic parts, as flexible molds, and as cloth coating dopes.

> **. . . selection of a material that will display proper behavior in a given service must rest on a balancing of many attributes, qualitatively appraised . . .**
> **—H. W. Gillett**



PRODUCTION

AND

DESIGN

COLD HEADING

Recent developments in this familiar production technique have opened new opportunities for cost saving in design

By Frank C. Boyd

Process Engineer

Townsend Co.

New Brighton, Pa.

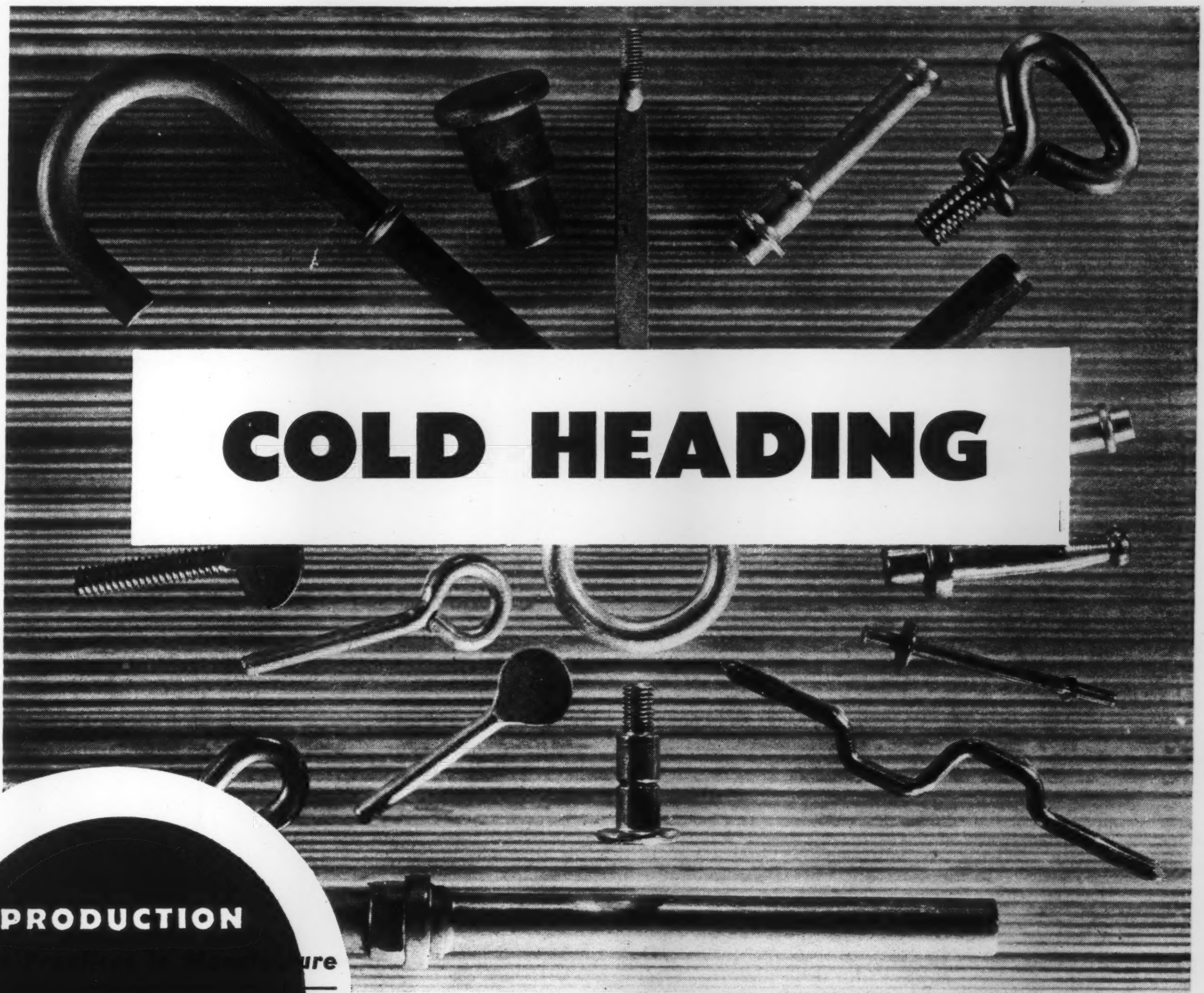


Fig. 1—Top—Array of cold-headed products, showing adaptation of cold heading and thread rolling. Many different shapes can be made within the limitations of these processes

A DESIGN engineer trying to create products which can be made at the lowest possible cost might well examine the advantages of design for cold heading. Cold heading—also known as cold upsetting or cold forging—has become useful in producing a vast new range of products, due to recent improvements in dies and other technological advances.

Development of tungsten carbide dies has made much longer production runs possible on cold heading machines while tolerances are still maintained. Improvements in tool design and in the quality of steel and other materials specially produced for cold heading also have opened new markets for cold heading. And, finally, cold heading equipment has undergone radical improvements.

Design or redesign of parts to be produced by cold heading or a combination of cold heading with secondary operations can provide significant cost savings. Although most headed parts are standard rivets, bolts, nuts, and screws, recent years have brought many developments in special headed parts which may or may not be fasteners, *Fig.* 1.

Heading Process: Cold heading is done on machines of basically one of two types—open die or solid die headers, *Fig.* 2. Both are made to do their job in either one or two blows. In addition, there are triple-stroke headers and multiple-station machines which use several dies and require the

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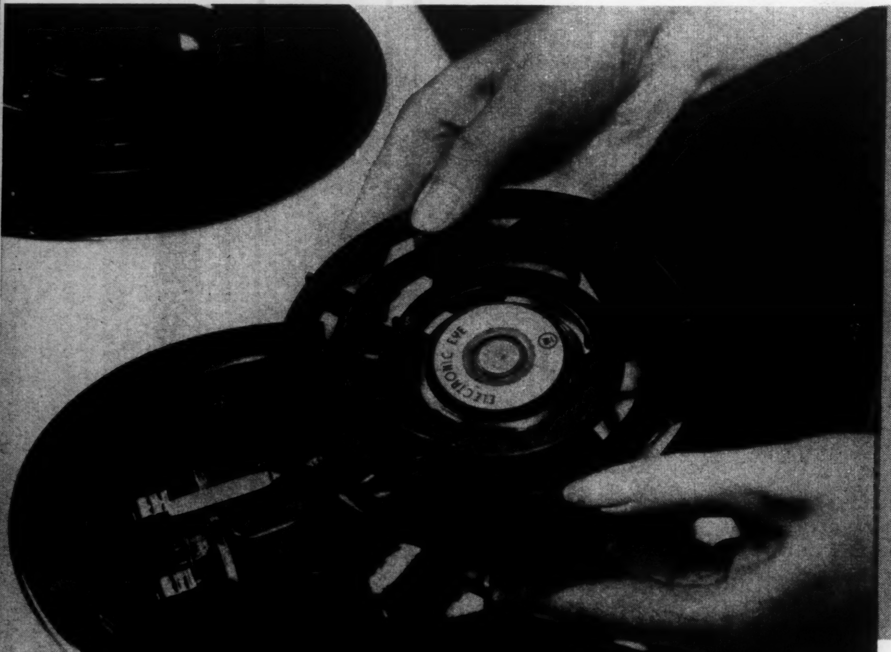

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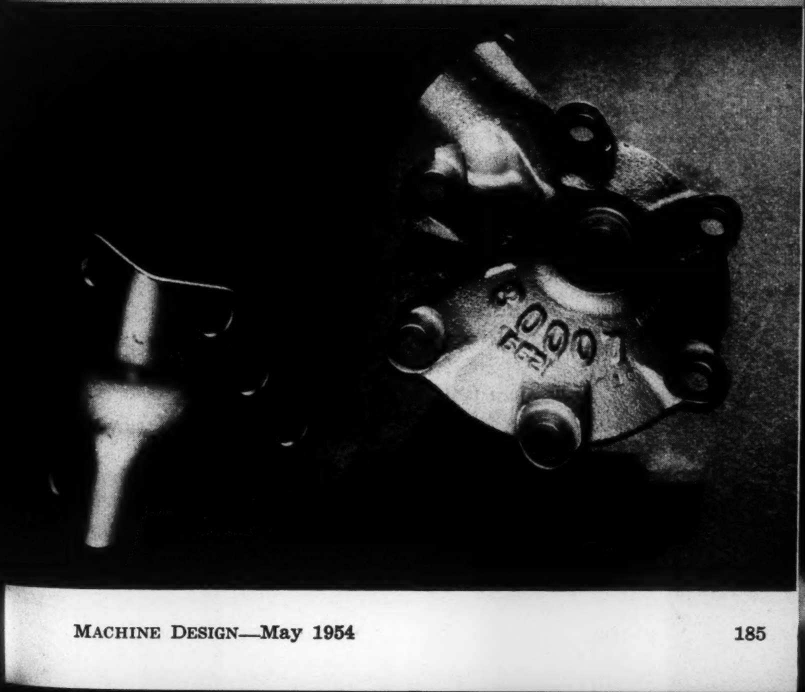
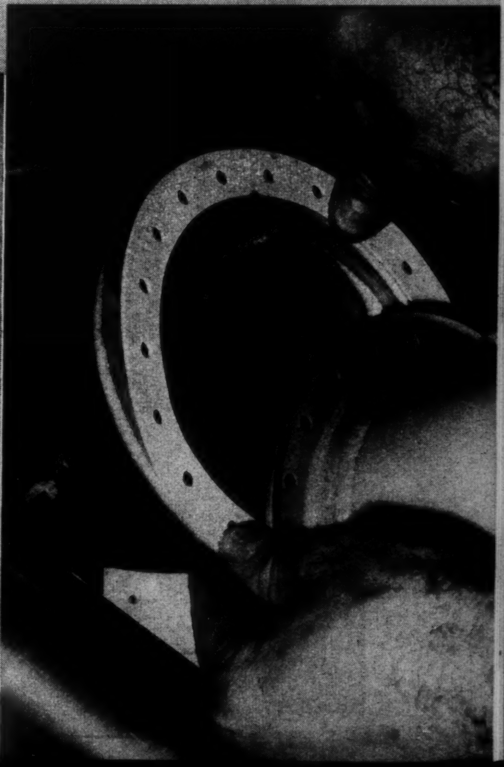


Fig. 3—Silicone rubber gaskets in aircraft cabin heating and pressurizing systems must stay elastic at temperatures from −70 to 400 F



foamed in place, made up as a sandwich construction or produced in various shapes and machined with conventional woodworking tools. Properties of these foamed resins suggest their potential usefulness as fire walls and as thermal or electrical insulating bodies.

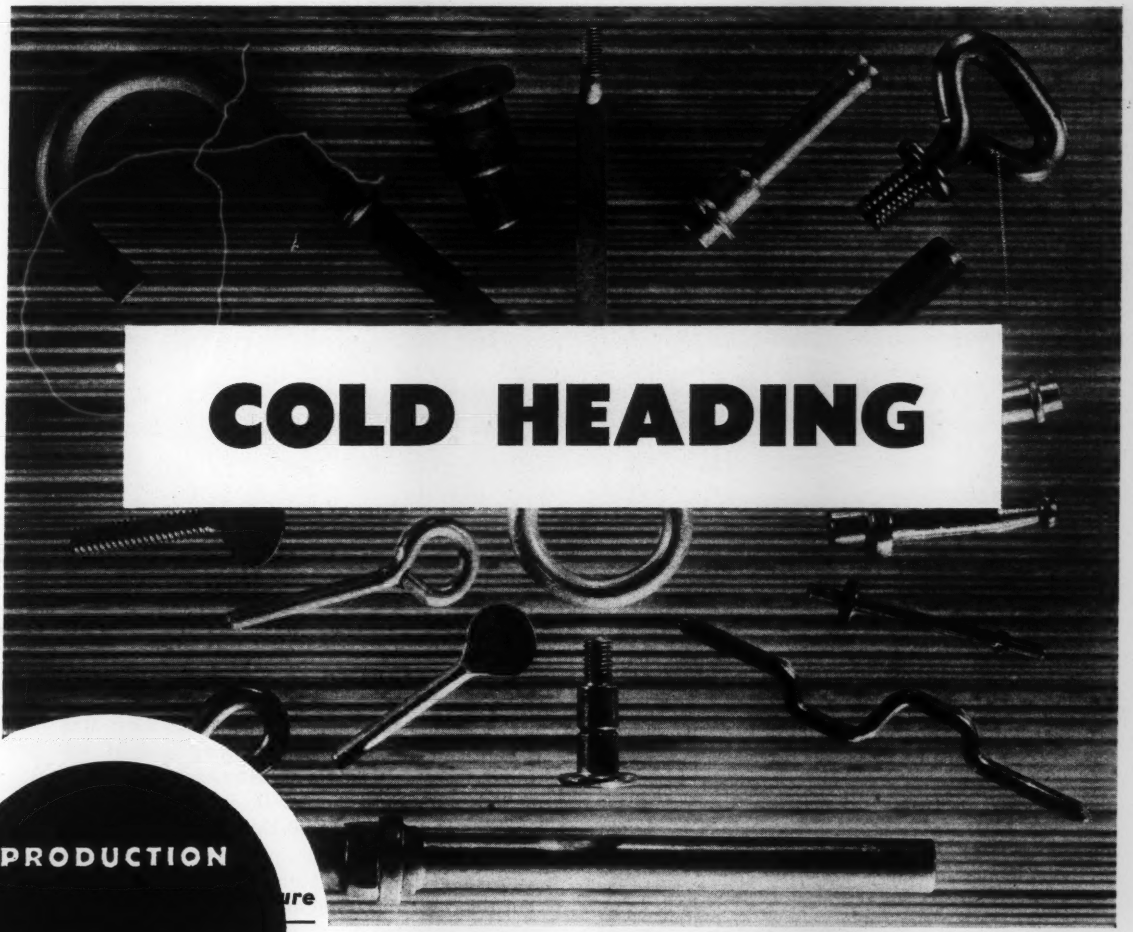
New among silicone rubbers is a stock in which low shrinkage and high resistance to permanent compression set are combined with serviceability at temperatures ranging from −100 to +500 F. Typical samples molded of this Silastic stock show a shrinkage of less than 2.5 per cent after 1000 hours at 390 F, and less than 7 per cent after 1000 hours at 480 F. Compression set after 22 hours under load at 300 F is in the range of 15 to 20 per cent. After 70 hours at 300 F, compression set is still only 20 to 28 per cent. And, unlike many silicone rubbers compounded for low compression set, this Silastic stock contains no toxic ingredients. It can therefore be used as a gasketing or sealing material in contact with cosmetics, foods or pharmaceuticals.

Most unusual among silicone rubbers is a series of new stocks that vulcanize and cure at room temperature. After seven days at room temperature these stocks develop a Durometer hardness of 20 to 30, tensile strengths of 185 to 325 psi, elongations in the range of 300 to 400 per cent, brittle points ranging from −80 to −110 F, and dielectric strengths of 500 to 550 volts per mil depending on the stock selected. In addition to good low-temperature flexibility, these materials are serviceable at temperatures in the range of 300 to 500 F. They are designed for a wide variety of uses where the remarkable stability characteristics of silicone rubber are required in applications where high curing temperatures cannot be attained or tolerated. Their properties suggest a wide field of usefulness as caulking, sealing or glazing materials, as potting or encapsulating materials for electrical assemblies and electronic parts, as flexible molds, and as cloth coating dopes.

> **. . . selection of a material that will display proper behavior in a given service must rest on a balancing of many attributes, qualitatively appraised . . .**
> **—H. W. Gillett**

MATERIALS FOR SPECIAL SERVICE

COLD HEADING



PRODUCTION

AND

DESIGN

Recent developments in this familiar production technique have opened new opportunities for cost saving in design

By Frank C. Boyd
Process Engineer
Townsend Co.
New Brighton, Pa.

A DESIGN engineer trying to create products which can be made at the lowest possible cost might well examine the advantages of design for cold heading. Cold heading—also known as cold upsetting or cold forging—has become useful in producing a vast new range of products, due to recent improvements in dies and other technological advances.

Development of tungsten carbide dies has made much longer production runs possible on cold heading machines while tolerances are still maintained. Improvements in tool design and in the quality of steel and other materials specially produced for cold heading also have opened new markets for cold heading. And, finally, cold heading equipment has undergone radical improvements.

Design or redesign of parts to be produced by cold heading or a combination of cold heading with secondary operations can provide significant cost savings. Although most headed parts are standard rivets, bolts, nuts, and screws, recent years have brought many developments in special headed parts which may or may not be fasteners, *Fig.* 1.

Fig. 1—Top—Array of cold-headed products, showing adaptation of cold heading and thread rolling. Many different shapes can be made within the limitations of these processes

Heading Process: Cold heading is done on machines of basically one of two types—open die or solid die headers, *Fig.* 2. Both are made to do their job in either one or two blows. In addition, there are triple-stroke headers and multiple-station machines which use several dies and require the

Fig. 2—Right — Battery of cold-heading machines capable of high-volume production at low unit cost

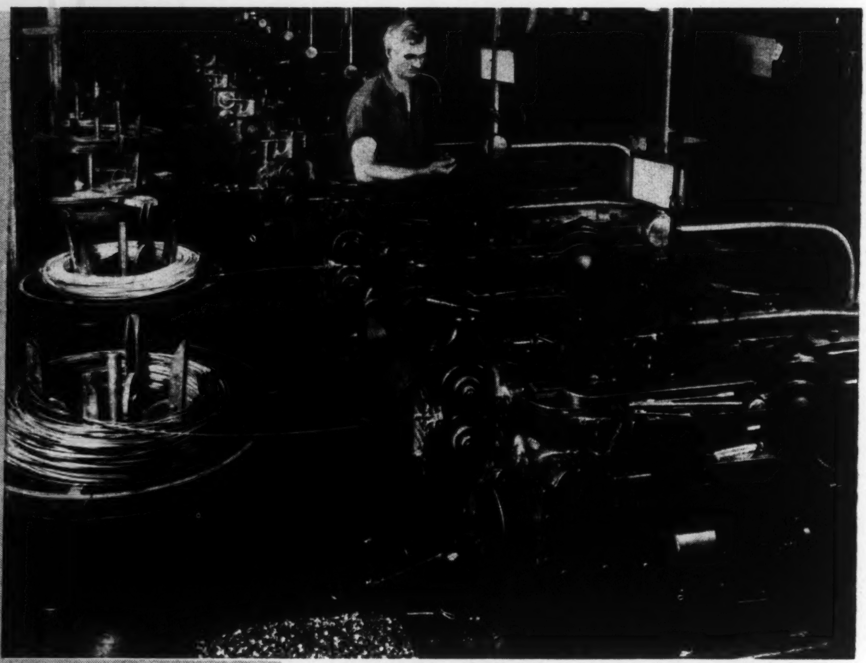


Fig. 3 — Below — A typical part requiring 2⅜ inches of ¾-inch diameter barstock weighing 0.410-pound for production on a screw machine. An approximately identical part produced by upsetting takes 3 5/16 inch of 0.445-inch wire weighing 0.297 pound

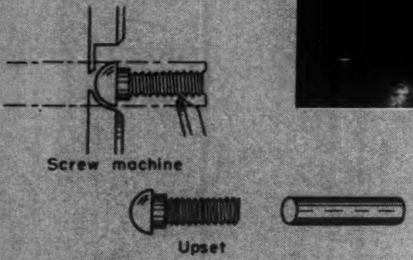


Fig. 4—Possibilities for redesigning shoulder work, illustrating the cubic volume of metal that can be handled in the cold-forging process. Either redesign *b* or *c* will upset very freely by double blow

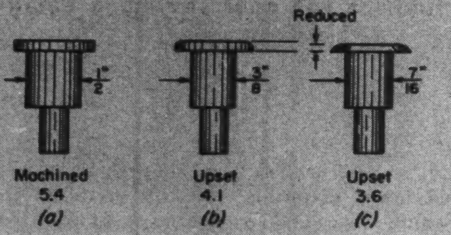
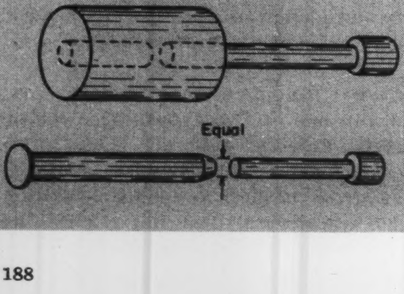


Fig. 5—Solid-die heading showing variation in diameter of knockout pin which is controlled by dimensions of point on blank



transfer of material from station to station.

The sequence of operations on cold-heading machines can be performed at the rate of 400 per minute on small, single-stroke headers or at the rate of 250 per minute on small, double-stroke headers. Speeds range down to 50 blanks per minute on very large headers.

Advantages of Heading: Pinpointing the importance of cold heading as a production process, the advantages of cold-headed parts are:

1. There is frequently a large saving in material because there is virtually no scrap in the cold-heading operation. In screw-machine processing varying amounts of scrap are left from cutting operations.
2. Tensile strength of metals is increased by cold working.
3. There is better fatigue and shock resistance in the headed part because the flow lines of the material follow the contours of the upset section. Also, the corner fillets which are required in cold heading aid in furnishing uniform flow lines.
4. Quality is high because material used for cold heading is special quality wire which is ductile and highly resistant to cracking.
5. Surface finish is excellent for most purposes.
6. All sections of screw machine parts must be symmetrical and concentric, whereas cold-headed parts can usually be produced with offsets, wings, flats or ovals. This is important in the design of inserts which rely on their shape to prevent turning.
7. Unit costs are relatively low because of high production rates. This is frequently true even when cold-headed blanks are finished by one or more secondary operations—such as threading, machining or trimming, flattening, bending and the like.

Often, the savings in time and material resulting from cold-heading methods bring substantial cost reductions ranging up to $30 and $40 per thousand pieces, *Fig.* 3.

Design for Heading: Cold heading does have limitations and careful evaluation will help determine which products can or cannot benefit from its use.

The volume of material which can be upset is limited. The limitations on volume vary according to the type of material used, the shape of the upset and the original shank diameter. The farther the blank extends beyond the face of the die, the greater the chance the material will bend. For this upsetting a few rules of thumb have been developed. One is that the maximum upset diameter should not exceed twice the shank diameter for each blow. Another is that the maximum amount of material should not exceed 4½ times the diameter of the wire being upset, *Fig.* 4. Special machines and special methods sometimes make possible much greater upsets when required.

The length of a shank which can be produced in a solid die is limited. Here, the rule of thumb says the practical length limit is nine times the diameter of the shank. This amount can occasionally be exceeded under favorable conditions.

The principle of solid-die heading is shown in *Fig.* 5. Generally, the knockout pin in the die is the same diameter as the blank. But when a point is required on the blank, the pin assumes the diameter of the pointed end and not the shank diameter.

Almost any style of point can readily be produced by cutting or turning operations, *Fig.* 6, but to produce economical cold-upset die points, certain principles are involved. For example, at *Fig.* 6*c* is shown a 45-degree point, 1/16-inch long, with a ⅛-inch end diameter. This means that a ⅛-inch knockout pin must punch the finished blank out of the solid die which has formed the pointed end. One of the accepted principles in solid die work is that it is generally impossible to knock out a part more than 12 times the pin diameter in length. Thus, a screw or rivet more than 12 × ⅛-inch pin, (or 1½ inches long) could not be made with this die point. Changing to 20 degrees on a side by the same length point, as at *Fig.* 6*d*, produces an increased pin diameter of 0.170-inch. With this point a part or blank slightly over 2 inches long could readily be produced. With a 15-degree angle on a side, as at *Fig.* 6*e*, a 0.180-inch pin could be used, and a blank or part 2 5/32 inches long can be die pointed.

The possibilities of reducing wire diameter by extrusion to produce various parts are sometimes important. Generally speaking, an angle is necessary to make the material squirt or extrude down to a smaller diameter. It has been accepted that an angle close to 15 degrees on a side is necessary for best results. It is also accepted that approximately 20 per cent reduction is the best that can be handled in one step. Parts *a* and *b* of *Fig.* 7 are parts practical to make. There are many variations possible using these basic rules as guides.

A headless part such as at *Fig.* 7*c* illustrates one type of product on which greater reductions are quite possible and is an exception to these general rules. Another design, *Fig.* 7*d*, which is easily made, eliminates the angle joining the two diameters and it, therefore, is a second exception to the general rules. However, it is not practical to make such parts without special attachments on cold headers. This part illustrates a direct violation of the rules generally employed to show practical design. The part shown at *Fig.* 7*e* is purely a volume problem and is not extruded or reduced, but it does show a good example of a part practical to produce by cold heading.

While considerable success has been found with cold-headed products which require sharp corners, it is often difficult to fill such corners. Substantial radii are a great advantage in cold heading. Often a rounded corner can be used in a product

Fig. 7—Possibilities for reducing diameters by extrusion and cold-upsetting. Special header attachments are required for designs *c* and *d*, while at *e* the part shown is a practical example of cold-heading capabilities and is not extruded or reduced

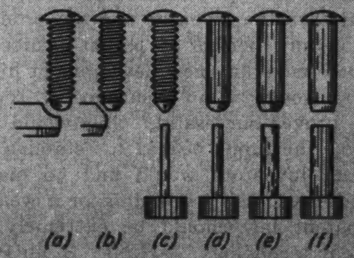
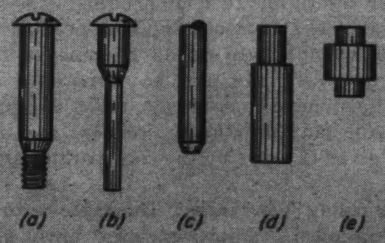


Fig. 6—Comparison of point styles possible with machining and cold upsetting. Length limitations imposed on solid die work by small points, *c*, can be remedied by decreasing the point angle as at *d*, *e*, and *f* to increase knockout pin diameter



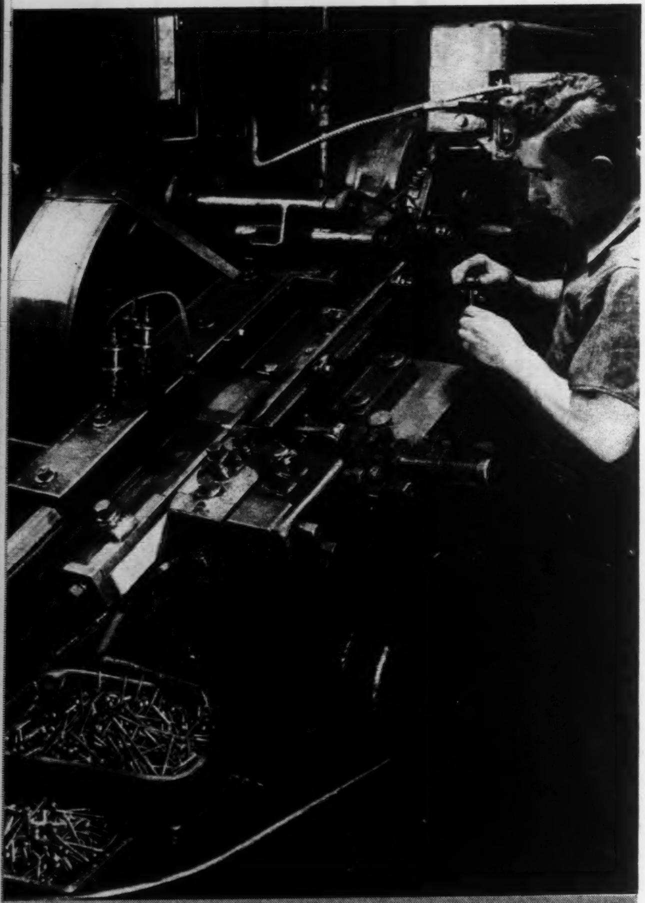


Fig. 8—Automatic thread-rolling machine. Threads made on these machines are accurate and can be produced at a high rate of speed without scrap

which formerly had a sharp corner without affecting the function of the part. Such changes in design have brought substantial economies.

In cold heading, square shoulders which are the same diameter across the flat as the shank are undesirable because they present a tooling and manufacturing problem. That problem is reduced if the shoulder can be made slightly larger than the shank.

Another limitation to cold heading is posed by internal stresses. Cold heading does produce stress conditions which often should be relieved by annealing, if use of the part so warrants. Sometimes a low-temperature strain relief is employed which will not drastically reduce the tensile strength given the part by the cold working process.

•

Cold Heading Tolerances: Tolerances can offer another problem. Improved dies have gone a long way toward solving the tolerance bugaboo by giving parts made at the end of the run the same approximate tolerance as parts made at the start, but cold heading still requires more liberal tolerances on some parts than machining operations.

Exceedingly close tolerances are not economical in cold heading because of the high cost of frequent die replacement and the reduced man hour output which results from close machine attention. Many times very close tolerances can be achieved on cold headers but not always on an economically sound basis.

Tolerances required vary directly with the diameter of material being headed and with the size of the machines something like the following:

Shank diameter, from 0.001 total to 0.015 total.
Shank length, from 0.005 total to 0.030 total.
Shoulder diameter, from 0.002 total to 0.020 total.
Shoulder length, from 0.004 total to 0.020 total.
Head or collar diameter, from 0.006 total to 0.060 total.
Head or collar thickness, from 0.004 total to 0.030 total.

Extreme concentricity requirements are difficult to hold on cold headers as compared with screw machines. This results from the fact that the upset is made by a moving punch and alignment depends on the condition of the machine and the skill of the operator.

•

Thread Rolling: Cold-rolled threads, closely allied to cold-heading parts, also offer savings. Thread rolling is actually a cold-forging process and produces a thread that is strong and tough. Because of precision manufacturing of rolling dies, it is possible to roll threads which are accurate and uniform. Thread rolling is very fast, with speeds ranging from 3000 to 30,000 pieces per hour on automatic machines, *Fig.* 8. In addition, there is considerable material saving since the blank from which the thread is rolled is smaller than the finished thread. On threads ½-inch in diameter and smaller, material savings range from 13 to 27 per cent depending on the particular thread diameter.

They Say . . .

"Technology progresses only when there are sufficient incentives to encourage both discovery and commercial development. The heart of this incentive is the American patent system. A good way to throttle all technology would be to change the law so that neither the inventor nor the producer could count on any period of patent protection. This would soon make any new development highly risky for there would be no assurance of reward if the project proved successful. This would very quickly shut off the funds needed to establish new technology, and inventors would find no market for their discoveries. So a crippling or a weakening of the patent law should be extremely embarassing to our technology."—HENRY B. DU PONT, *vice-president, E. I. du Pont de Nemours & Co.*

Engineering NEWS ROUNDUP

Engineer Enrollment Increased in 1953

Fall term enrollments at schools accredited by the Engineers Council for Professional Development increased by 8.4 per cent in 1953. Total number of engineering students enrolled is 171,832. These figures were recently published by the American Society for Engineering Education in the 1954 yearbook edition of the Society's Journal.

Enrollments at some of the nation's leading schools of engineering are:

School	Students	School	Students
Illinois Tech ..	5334	Ohio State	2949
Brooklyn Polytech	4805	Newark College.	2932
Purdue	4705	Texas A. & M. .	2655
U. of Illinois ..	4597	U. of Wisconsin	2499
CCNY	4495	Rensselaer Polytech	2497
Georgia Tech ..	3669	U. of Michigan.	2430
MIT	3380	Carnegie Tech..	1935
NYU	3218	Case Tech	1616
Penn State	3059	Columbia U. ...	1222

First Full Scale Atom Power Plant Proposed

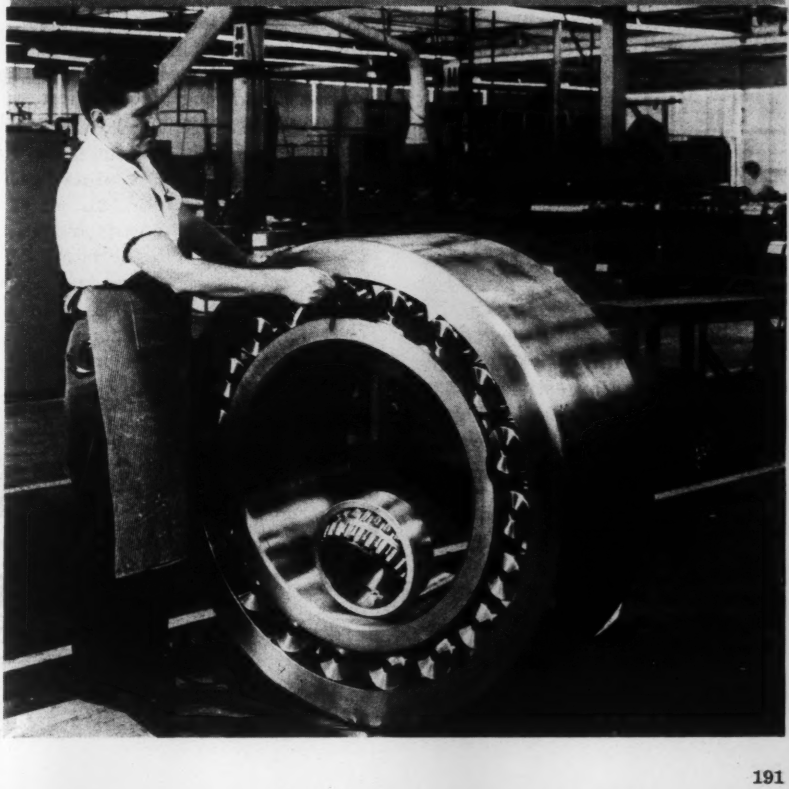
Nuclear produced electric power may be available in the Pittsburgh area in the future if the Atomic Energy Commission accepts the proposals submitted by Duquesne Light for participation in the construction and operation of a nuclear power plant.

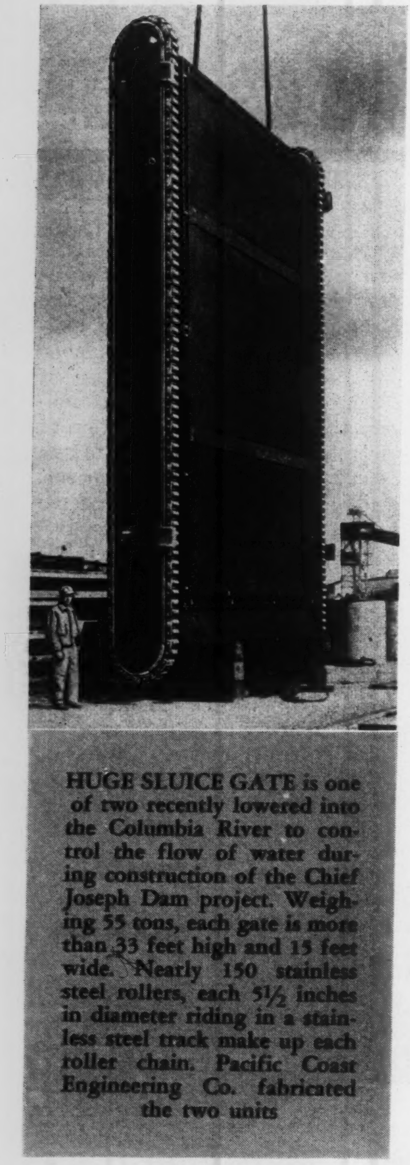
Design, development and construction of the reactor portion of the plant is under contract to Westinghouse. Expected to generate a minimum of 60,000 kilowatts of saleable electricity, the reactor will also produce sufficient heat to meet the electricity requirements of the plant itself.

Known as a pressurized water reactor (PWR) type, the reactor will be cooled and moderated by ordinary water under pressure. Using slightly enriched uranium as fuel, this type was selected because research and development is more advanced than on other types. To be located on a plant site within the Greater Pittsburgh area, the reactor will incorporate safety features developed through ten years of experience with reactor operation.

Under the proposal, Duquesne will furnish the site and build and operate the generating plant at no cost to the Government. Operation of the reactor part of the plant will be handled by the company which will also bear the labor costs of such operation. Cost of research, development and construction of the reactor portion of the plant will be assumed to the extent of $5 million by Duquesne. Rates have been proposed for the sale of steam generated by the reactor, and this revenue with the

GIANT BEARING: Rated at 3½ million pounds, the largest of self-aligning spherical roller bearings has a tapered bore of over 48 inches, and each of the rollers weighs 39½ pounds. Made by SKF Industries for a tube reducer designed by Tube Reducing Corp. which will produce compression-formed precision tubing of sizes ranging from 9 to 17 inches OD, the bearing is shown with a smaller size, used in a smaller tube reducing machine





HUGE SLUICE GATE is one of two recently lowered into the Columbia River to control the flow of water during construction of the Chief Joseph Dam project. Weighing 55 tons, each gate is more than 33 feet high and 15 feet wide. Nearly 150 stainless steel rollers, each 5½ inches in diameter riding in a stainless steel track make up each roller chain. Pacific Coast Engineering Co. fabricated the two units

proposed co-operation by Duquesne would reduce by an estimated $30 million the expenditures the government would have to make if it undertook the full project.

How To Increase Supply of Engineers

Increasing numbers of scholarships being set up by industry for persons who cannot afford a college education is a bright spot in the elimination of economic barriers to higher education, noted Clarence E. Deakins, dean of students at Illinois Institute of Technology recently. Speaking at the National Association of Power Engineers meeting at Chicago, Deakins warned that the United States must make full use of its reservoir of brain power if it is to fulfill its role as leader in world affairs. An opportunity to invest in America's future by providing financial aid to bright high school students "lies right in the high school in your home town" he asserted. Results of surveys have shown that income of parents has prevented many of these students from going to college, and these economic barriers must be eliminated for those who have the capacity and interest to benefit by additional education.

First Turboprop Seaplane Takes to Air

Capturing a bit of the glory from some of its more glamorous contemporaries such as the supersonic jets and delta wing fighters, a 145-foot wingspan seaplane driven by four 5500-horsepower turboprop engines remained in the air more than two hours on its maiden flight. Lifting off the water at San Diego bay in less than 30 seconds, the 80 ton aircraft called the R3Y Tradewind (MACHINE DESIGN, Page 240 May, 1953), is the first of a fleet being built for the Navy by Convair.

Powered by four Allison T-40 turboprop engines which drive contrarotating propellers, the plane is designed for speeds exceeding 350 mph and is equipped with a high-altitude pressurized cabin and with air conditioning. Excellent maneuverability when afloat is possible by reversible pitch propellers which enable the R3Y to be turned around in its own length.

Multicell compartments built-in below the deck level provide watertight construction without the necessity of bulkheads. Extruded magnesium covered with plastic is used for the deck, which is parallel to the water line and at the same height as floating docks in order to facilitate cargo handling. Passenger seats in the R3Y face rearward.

Turbine bleed air is used for de-icing the stainless steel leading edges and also for operating the

More than 22,000 horsepower takes the Convair R3Y Tradewind transport off San Diego Bay on its maiden flight. To be operated by the Navy's Fleet Logistics Air Wing, Pacific Fleet, out of Alameda, Calif., the R3Y's will be able to cruise long distances at nearly twice the speed of existing transport flying boats

alternators supplying alternating current power. Controls and wiring are installed above the cabin behind easily removable overhead panels.

WRAP FORMING MACHINE can handle sheets to 6 feet wide and 30 feet long. The 400-ton capacity Sheridan press is installed at Convair's San Diego plant

Electronics Called Fastest Growing Industry

America's electronics industry currently is an $8 billion industry and within the next eight years its sales and revenues will probably exceed $13 billion annually, according to Frank W. Mansfield, director of sales research, Sylvania Electric Products Inc. Describing electronics as the world's fastest growing major industry, Mansfield said his estimates concerning its great future were based on "realistic projections" of trends that already are well established.

In one of the first appraisals of the present and future of the entire electronics field, prepared for delivery before the recent eastern regional conference sponsored by the New York Society of Security Analysts, Mr. Mansfield discussed the potential of electronic products for entertainment, including television and radio; products for national defense; equipment for industry and commerce; components for repair, including receiving tubes and television picture tubes; television and radio broadcasting revenues; and revenues to distribution channels.

RUGGED RUBBER HOSE is not cut, abraded or permanently distorted and maintained applied pressure of 400 psi though run over by a freight car wheel. Extremely flexible, the new heavy-duty hose is reinforced by a single braid of high-tensile steel wire. Labelled *Commander* by the makers, B. F. Goodrich Co., the hose is also oil resistant

Sales of radio receiving tubes, television picture tubes, special electronic tubes, and other components for repair purposes amounted to $600 million in 1953, and may come close to $850 million in 1954. In the 1957-59 period the annual average should be about $1.4 billion, and in 1960-62 repair parts sales are expected to exceed $2.2 billion.

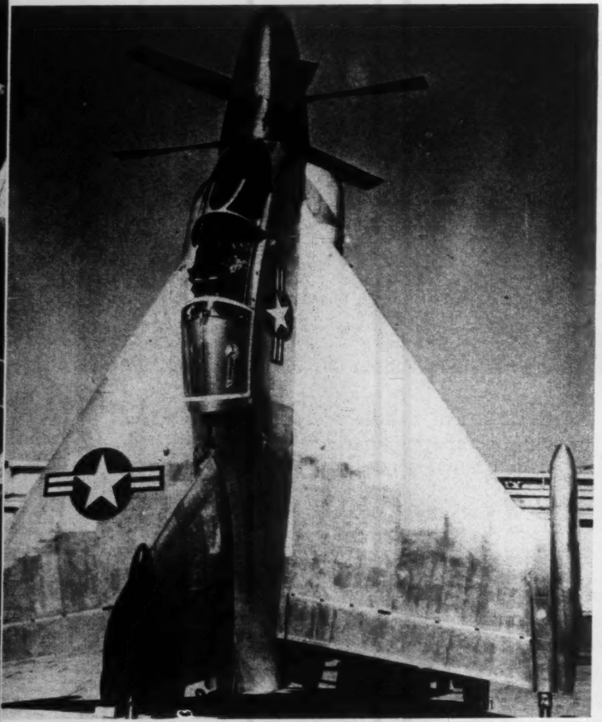
Mr. Mansfield reported that 7 million home radios were sold in 1953 for a total volume of $113 million, and that another 6 million sets, at a total of close to $100 million will be sold in 1954. He estimated that home radio set sales in the 1957-59 period would be nearly 7.8 million a year, at an annual volume of $126 million, and that the average unit sale in 1960-62 would be about 8.5 million sets, or nearly $138 million.

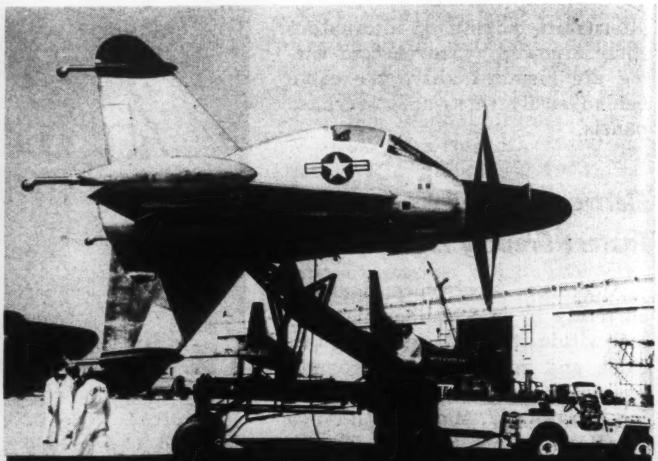
Approximately 5.2 million entertainment radios for automobiles, totaling $150 million were sold in 1953, and another 4.1 million sets aggregating $123 million are expected to be sold this year, he said. Auto set sales in 1957-59 and 1960-62 periods should average from 3.6 million to 3.8 million a year at a volume running between $108 million and $114 million.

"Mimi" Flys High Without Taking Off

Flight testing of guided missile controls without leaving the ground is accomplished with a new test device called "Mimi," a "missile mission" simulator developed at Northrop Aircraft Inc. Built for the U. S. Air Force, the simulator tests the controls of a guided missile by setting up a "flight" to a predesignated target and introducing elements such as atmospheric conditions that might throw the missile off course or otherwise affect its flight.

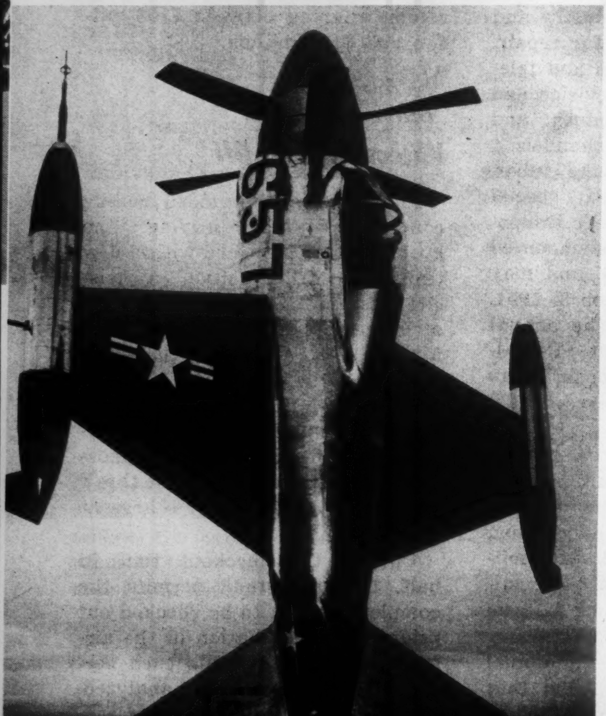
Cutting the checkout time in half, the test stand permits the complete system to be checked out prior to its installation in the airframe and also permits each section to be separately analyzed. Check points are provided to measure voltages, and signals are recorded on oscillographs to enable operating personnel to quickly discover, isolate and correct any existing missile malfunction.

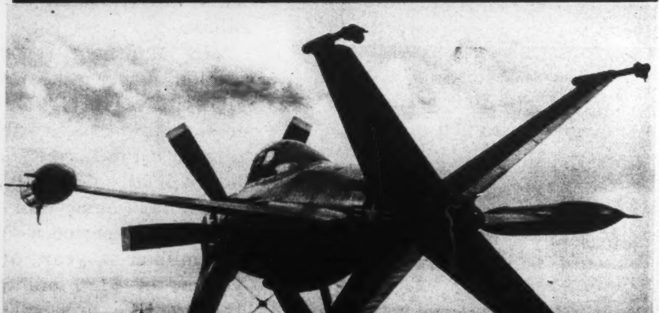




Vertical Risers

A new concept in aircraft design developed after nearly three years of secret research, these aircraft are now being preflight tested for the Navy. Two models, a delta-wing type constructed by Consolidated Vultee, above and left, and one constructed by Lockheed pictured, below and left, are expected to take off vertically. After getting into the air, they are designed to level off and fly at speeds of approximately 500 miles per hour or can hover. When landing, they will be able to come straight down and rest on the tail. Equipped with contrarotating propellers, both are powered by turboprop enginges. Designed as convoy escort fighters, these aircraft will take off and land without the need for a carrier deck, in fact may land on a plot of ground about the size of a tennis court.





Auto Gas Turbine Combines Economy, Performance

A gas turbine engine capable of operating a current model automobile in city or highway traffic has been developed by Chrysler Corp. It is now undergoing road tests at the company's proving grounds in a Plymouth coupe. Fuel economy of the turbine is said to equal that of conventional automobile engines and its exhaust is cooler than that discharged by the average car. Performance is said to be superior to that of piston engines of comparable horsepower.

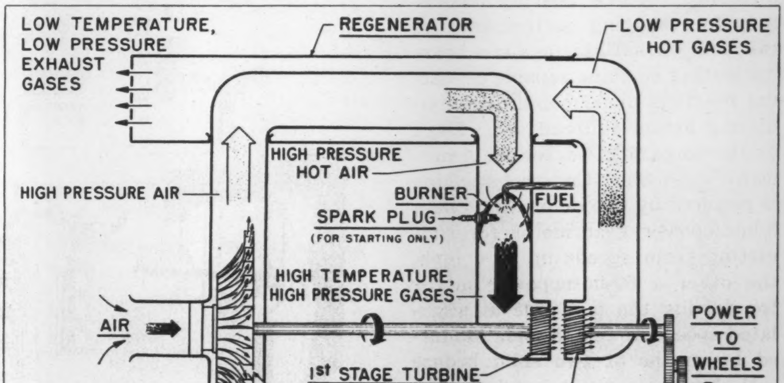
Almost 200 pounds lighter and having less than one-fifth as many moving parts as a piston engine of comparable power, the Chrysler gas turbine with reduction gears is only 32 inches long, 33 inches wide and 28 inches high. It fits easily into the engine compartment of the 1954 Plymouth coupe in which it is shown being installed

High fuel consumption and exhaust heat have been two of the chief stumbling blocks in the path of automotive gas turbines. Key to the Chrysler turbine engine's fuel economy and cool exhaust, is a heat exchanger or regenerator, which utilizes most of the heat discharged as waste by conventional gas turbines. This heat is transferred to the incoming flow of fresh air in the regenerator and becomes available as useful energy to drive the wheels of the car. Heat exchangers of the efficiency and capacity needed to provide fuel economy comparable to that of automobiles now in everyday use, have previously been too large to install in a passenger car.

Although the Chrysler turbine engine is rated at 120 shaft horsepower, Mr. George J. Huebner Jr., executive engineer in charge of research, who directed development, design and testing of the turbine, said, "because of its torque characteristics, it delivers essentially the same performance at the rear wheels as a 160-horsepower piston engine with transmission." Unlike the automotive piston-type engine, the gas turbine delivers its highest torque during breakaway from a stationary position. Moreover, the torque available for acceleration from any given speed within the range of the turbine-powered car is much greater than that produced by piston engines and transmissions.

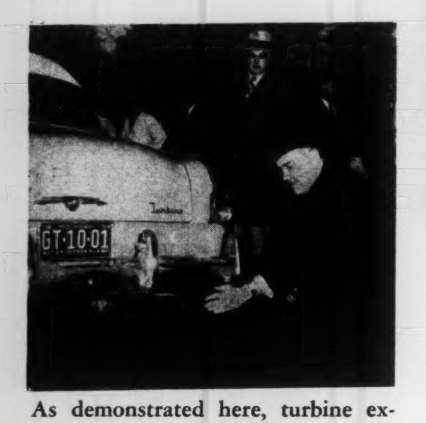
In the proving grounds tests, the Chrysler gas turbine burned straight-run gasoline, carried in a standard 17-gallon Plymouth fuel tank. However, any of a wide range of petroleum fuels may be used, from gasoline to heavy fuel oil. Since the turbine is air-cooled, it requires no radiator or liquid cooling system. The closest thing to a radiator is a small, finned cooling tube for the lubricating oil. This is mounted in the intake air passage. Electrical system consists of a storage battery, starter-generator, coil, breaker and a single spark plug—which is needed only in starting. A transmission is used in the present test model for the sole purpose of providing a reverse gear.

Development of the Chrysler regenerative gas turbine does not mean that such an engine is ready for general use, according to Mr. James C. Zeder, vice president and director of engineering and re-


LOW TEMPERATURE, LOW PRESSURE EXHAUST GASES
REGENERATOR
LOW PRESSURE HOT GASES
HIGH PRESSURE HOT AIR
HIGH PRESSURE AIR
BURNER
FUEL
SPARK PLUG (FOR STARTING ONLY)
HIGH TEMPERATURE, HIGH PRESSURE GASES
AIR
POWER TO WHEELS
1st STAGE TURBINE (DRIVES COMPRESSOR)
COMPRESSOR
2nd STAGE TURBINE (DRIVES CAR)

Schematic diagram of Chrysler gas turbine engine

search. "Whether we ultimately shall see commercial production of gas turbines for passenger cars," Mr. Zeder said, "depends on the long-range solution of many complex metallurgical and manufacturing problems. There is no telling at this time how long it will take to solve these problems. Also, the limited supply of such strategic materials as nickel, cobalt, tungsten, molybdenum and chromium currently prohibits the use of gas turbines in automobiles except on an experimental basis."

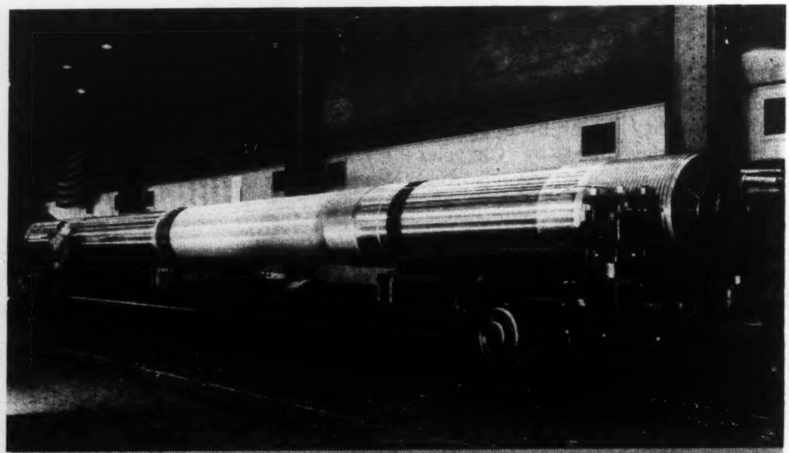


As demonstrated here, turbine exhaust gases are cooled in the regenerator to the extent that they constitute no hazard

New Testing Lab To Eliminate Hot Boxes

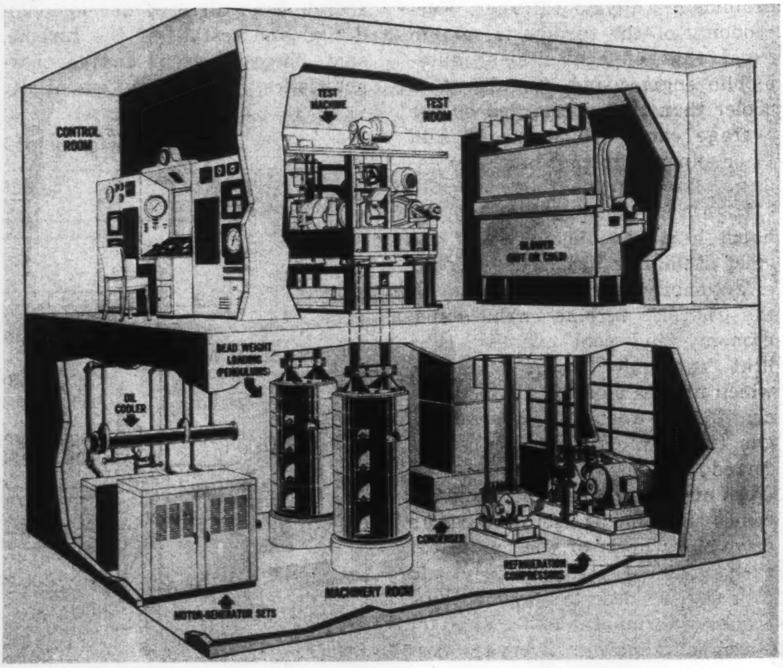
Heart of a new bearing laboratory for studying performance of railroad journal bearings is a bearing testing machine capable of testing bearings under conditions simulating actual railroad use. Built by Hardinge Mfg. Co. for the American Brake Shoe Co., the machine is powered by two dc motors, one a 5-horsepower gear motor for simulating train speeds up to 6 mph, the other a 60-horsepower motor for driving the test axle at simulated speeds up to 115 mph. Mounted by means of two solid bronze self-aligning support bearings, the test axle is fitted with a replaceable stub at each end finished to AAR specifications. Standard journal boxes, roller bearing assemblies, or other devices may be installed over the two journals which are replaceable, permitting destructive tests to be run.

Loading of each journal is accomplished by a yoke with two arms that straddle the box and extend into a room below where weights may be hung on as desired. Comprising a huge pendu-



COLOSSAL COLUMN of forged steel weighs 181,000 pounds. One of eight to be used in a 35,000 ton forging press, the column is approximately 60 feet long and 3 feet in diameter. It is pictured being turned on a 72-inch engine lathe with a 75-foot bed at a United Engineering and Foundry Co. plant

Cutaway view of the new Railroad Bearing Laboratory of the American Brake Shoe Co. shows the test room, control room, and machinery room



Industry's Widest Range

OF SLEEVE BEARING TYPES & SIZES

In this photo you will find a Johnson Sleeve Bearing of every type used in industry. Various alloys . . . bronze, babbitt or aluminum . . . can be selected . . . and different combinations with bronze or steel are available. Johnson Bronze facilities make possible a size range from tiny bearings up to King Size, 14" OD, 17 inches in length. Since Johnson Bronze produces all the types of sleeve bearings, their engineers can give you unbiased advice on the bearing best suited to your application.

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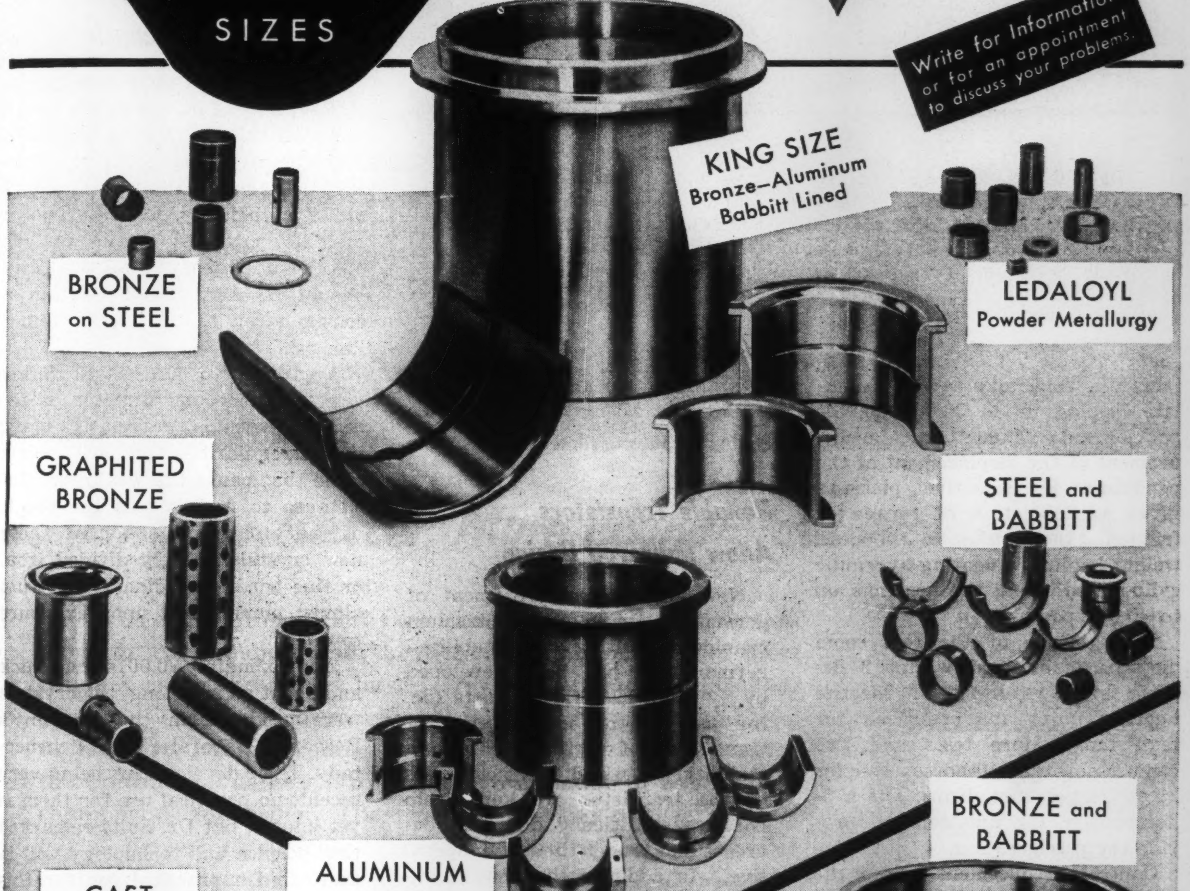
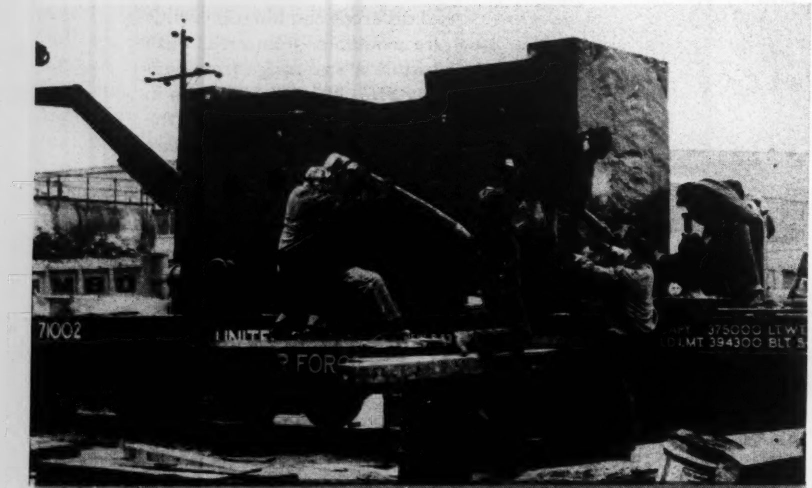
JOHNSON JB BEARINGS
Sleeve-Type

Write for Information or for an appointment to discuss your problems.


KING SIZE
Bronze–Aluminum
Babbitt Lined
BRONZE on STEEL
LEDALOYL
Powder Metallurgy
GRAPHITED BRONZE
STEEL and BABBITT
BRONZE and BABBITT
ALUMINUM ALLOY
CAST BRONZE
ALUMINUM on STEEL



GIANT ANVIL BASE, for one of two 50,000-pound drop forge hammers, weighs 390,000 pounds. Anvil is one-third of the 42 by 36 by 23½ foot deep foundation which will also use 5½ million pounds of concrete and reinforcing steel. Entire installation, being made at Kropp Forge Co. will weigh nearly 8 million pounds

lum, the yoke and weights simulate loading up to 20,000 pounds per journal. Under test, a measurement of the displacement of the pendulum by sensitive pick-ups gives an indication of torque or friction. In addition to the dead weight loading, a floating hydraulic cylinder will load the bearings up to 40,000 pounds.

Temperature of the test room may be maintained within 2 degrees from −40 to 125 F. Electric heating units are energized for high temperature tests and two compressors, one 40-horsepower for large temperature drops, and a 5-horsepower for fine control, provide the refrigeration.

Control of equipment is from the operator's panel in the control room. Recording of all functions is on paper tape while a microphone and tape recorder provide for any verbal comment the operator may wish to make during the test.

Other facilities include equipment for making standard tests on lubricants and materials and a special machine designed for testing bond strength of journal bearing linings. Special test stands for preliminary checking of any particular lubricating device are also provided.

Reliable Transistors Allow Improved Design

New special heat treatment of germanium in molten potassium cyanide, resulting in "stabilized germanium," has been developed by Sylvania Electric Products Inc. for use in the manufacture of transistors of increased life and stability. Desired characteristics of the transistor are kept from changing, efficiency does not decrease and render the unit inoperative. In addition the new stabilized germanium is immune to surface moisture and will not deteriorate under conditions of extreme humidity.

High - temperature transistors also have been developed using new germanium - silicon alloys which enable the units to operate at temperatures up to 350 F. High atmospheric heat, heat from surrounding equipment, and heat dissipated by the transistor itself will adversely affect its performance; however, the use of these alloys is said to permit the application of transistors in equipment subject to high temperature conditions.

One of the greatest obstacles to transistorizing present military and industrial equipment has been the instability of the units themselves. Having been overcome by these two developments, new equipment of reduced size and lower cost may be designed.

Perfect Iron Crystals Reach Highest Strength

Development of theoretically perfect crystals of pure iron, for which no practical use has as yet been found, was announced by General Electric. One-hundred times stronger then any presently known metallic crystals, they are as strong as theory predicts they should be and actually attain a tensile strength of nearly a million psi.

According to Dr. C. G. Suits, vice president and director of research, crystals previously made had irregularities on an atomic scale that cause the weakness. Resistance to rust is also the result of the atomic perfection of these new crystals. Finely divided iron, or fine wires of ordinary iron rust almost immediately upon exposure to air.

Approximately 0.001-inch thick and about an inch long, the crystals were produced in the company's Research Laboratory in Schenectady. Their development being very recent, no practical use for them is yet known, but Dr. Suits remarked that science and technology will in time, find a practical use for this form of metal.

A new $100,000 electrical engineering laboratory—only one of its kind existing in an educational institution in the world—has been donated to Carnegie Institute of Technology by Westinghouse Electric Corp. With the new equipment, Carnegie Tech will be able to set up a miniature power system close-

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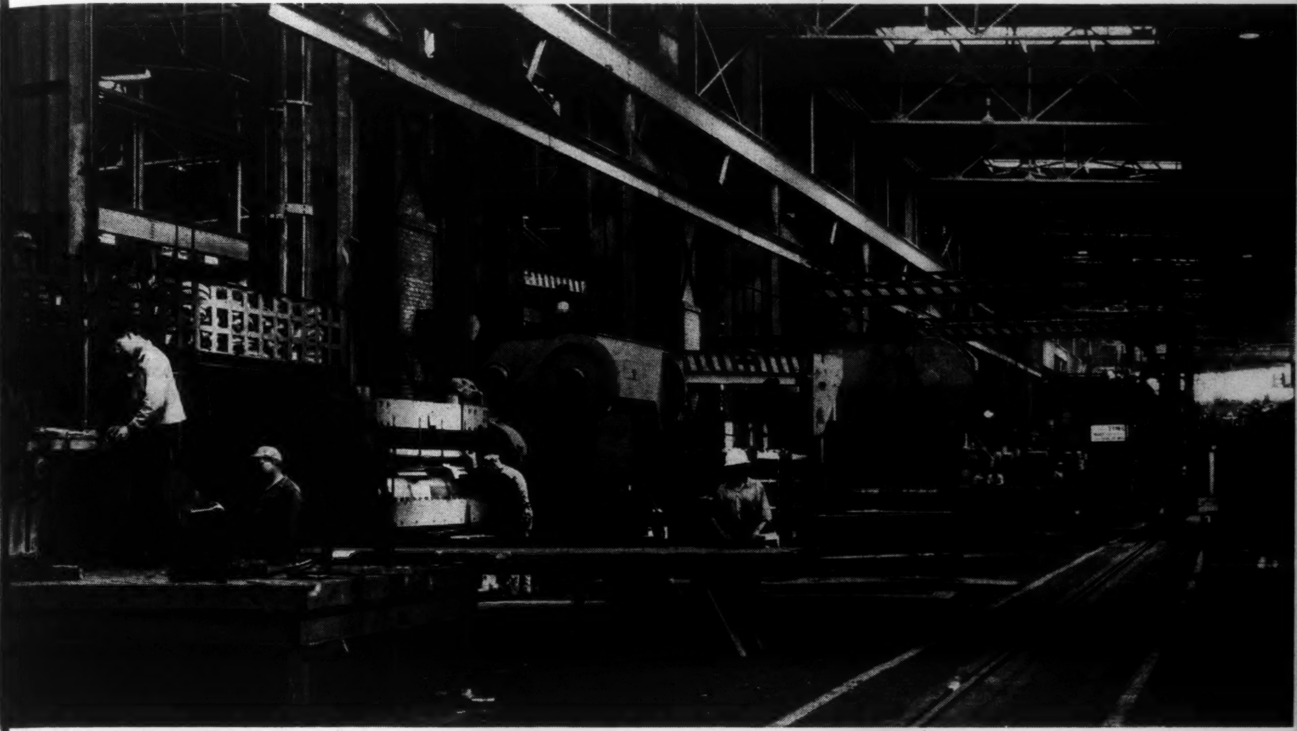
WELDMENT FACILITIES TO SERVE ALL INDUSTRIES



Looking for Better, More Economical Weldments?

Here you can get them. Here men know how to work with metals. How to cut, shape, weld, heat-treat and machine the most complex assemblies. They have learned by producing thousands of varied weldments for machinery builders and other industrial users . . . by building rolling mills and special machinery bearing the Continental name . . . by wartime production of welded tank components and armor. They have tools—the steel fabricating bay is shown—to cut costs. They work under scientific quality control—from production of needed castings to finished assembly. Call in a Continental engineer to help you find better, more economical weldments for your production needs.

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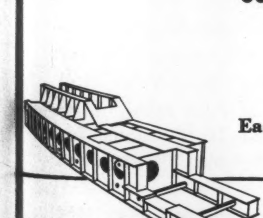

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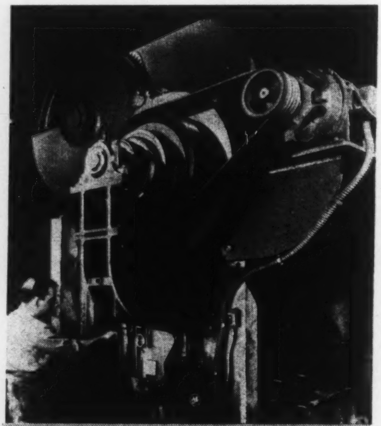
ly duplicating actual transmission lines and interconnected generator stations. The laboratory was designed to solve problems dealing with voltage regulators, transient characteristics, exciter characteristics within stability limits and subtransient reactances. Although Westinghouse may still use the equipment in the solution of possible future problems, all data gathered will be made available to the electrical industry.

Research Techniques Aid in Industry Planning

Organized research techniques are helping to determine the optimum aims and policies of industrial firms according to Dr. J. E. Hobson, director of Stanford Research Institute. However, he pointed out, industry must recognize that the goals set for applied research should be compatible with the company's financial capabilities, market conditions, and economic trends.

Dr. Hobson added that, "research executives have moved up into the policy-making stratum of the corporate hierarchy. Bankers and financiers have begun to take a detailed interest in corporate research policies, often establishing conditions of support on the amount and soundness of the research effort." He believes that the use of scientific techniques for company planning will result in fewer management mistakes.

Hot rolled magnesium plate, 6 feet wide and in lengths up to 60 feet, is now being produced from 2000 pound ingots by the Magnesium Dept., Dow Chemical Co. The plate is produced on an 84-inch reversing breakdown coil mill, the largest rolling unit ever constructed for magnesium. Previous production has been on hand mills using ingots weighing up to 350 pounds. An 84-inch cold coil mill for finish rolling of thin gage magnesium sheet is also being installed and should now be in operation.



COMPACT POWER PACKAGE has driven sheave integral with the flywheel, and a clutch inside the combination. Taper-Lock driving sheave is used on the motor-shaft. The unit was designed and assembled by Dodge Mfg. Corp. for Dreis & Krump

Want A Reactor? Here's A Catalog

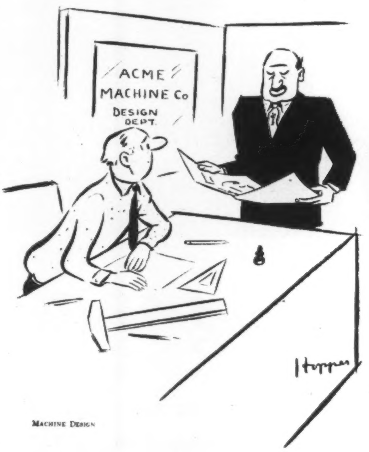
Listing three basic types of atomic reactors, a new catalog released by North American Aviation is a "first" in the nuclear field. Indicating progress in the design and construction of nuclear machines, the list describes standard types of reactors that will be built by North American for qualified scientific and industrial groups. Each of the types are designed to meet specialized nuclear research requirements. They are the solution type, pool type and the homogeneous graphite type.

Known also as the "water boiler", the solution type is arranged with the fissionable material contained in a water solution in the core. It has proved to be highly satisfactory as a general purpose type of reactor with a power rating of about 50 kilowatts.

Largest of the three reactors described, the pool type is rated at 100 to 1000 kilowatts. It uses highly enriched uranium and aluminum alloy as the core and is the most flexible of these offered.

Because of the large volume of the reactor core, the homogenous graphite reactor is recommended for applications involving a maximum of experimentation. A large number of simultaneous irradiations may be made with a minimum effect on reactivity.

None of the reactors cataloged are designed to produce electric power but are suitable for high neutron and other radiation production necessary in atomic research. North American is now engaged in the design of a reactor to produce economical electric power.

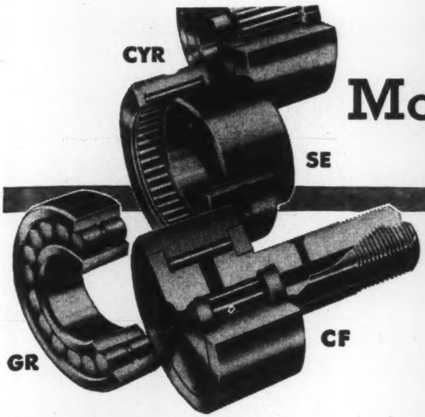


"Good! Now can you design a machine to machine this machine you've designed?"

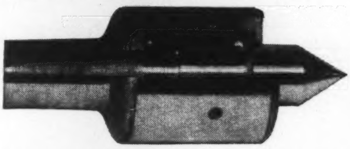
Product development contest, with first prizes of $1000 for the best paper in each of two classes, has been announced by the Steel Founders' Society of America. Among its purposes are the promotion of new ideas as they apply to steel castings and the encouragement of engineers and designers to become more familiar with engineering properties and characteristics of cast steel. Further details and instructions for submitting entries may be obtained

(Advertisement)

McGILL BEARING BRIEFS

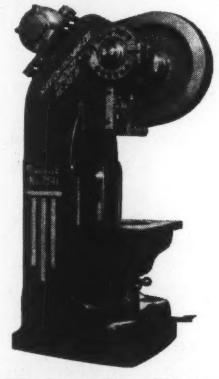


MOTOR TOOL LIVE CENTERS DEPEND UPON McGILL FOR HIGH RADIAL ACCURACY

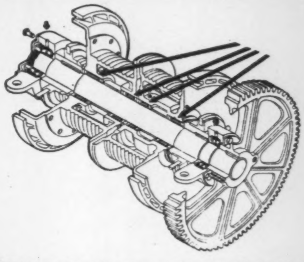


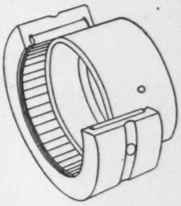
Multirol SE Bearings, press fitted into Motor Tool Live Centers, "account for accuracy and long life of these units." They take the radial loads of lathe, screw machine and grinder operation without radial looseness or play.

ROUSSELLE PRESSES USE MULTIROL SE BEARINGS EXCLUSIVELY FOR 8 YEARS



Service Machine Co., Chicago, have used Multirol SE Bearings exclusively for over 8 years on their Rousselle heavy duty presses. Two SE Bearings mounted side by side, support and carry the heavy fly wheel load on all 15, 25, and 40 ton models.





MULTIROL® *SE Bearings* CARRY HEAVIER LOADS MORE ECONOMICALLY

On Baldwin-Lima-Hamilton Cranes and Shovels

The heavy cable loads on the Hoist Drum Shaft of Cranes and Shovels require a heavy duty bearing that occupies a minimum of radial space. The Multirol SE Bearing provides the answer to dependable performance in this application. Its trouble-free operation under heavy loads with long life expectancy has effected considerable savings in service charges for users of Lima Cranes, Shovels, Draglines and Pull Shovels.

By packing more load carrying capacity into a smaller radial space, Multirol Bearings permit use of a larger shaft and a heavier drum section. This eliminates the tendency for the crushing load of the cable to bind the shaft and reduces shaft deflection.

Baldwin - Lima - Hamilton has been using Multirol Bearings for many years and depends on such design advantages as lubrication reservoirs above roll ends, one piece outer and roller retaining end shoulders, the sealing effect of close end shoulder and shaft clearance against foreign particles, etc. To get the same dependable and long lasting performance in your products, always specify McGill Bearings.

BEARING SELECTION GUIDE

A new 140-page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

McGILL® — Precision Bearings

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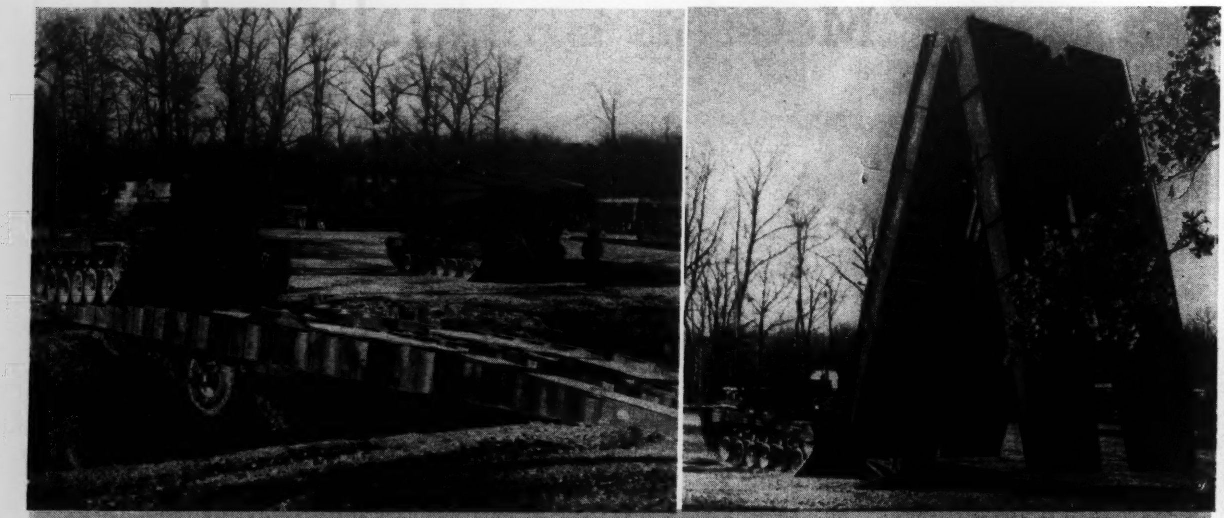


U. S. Army photos, courtesy, Ordnance Magazine.

BRIDGE-LAYING TANKS: Assault bridge, left foreground, it attached to a U. S. Army tank for positioning by linkage. It has a roadway width of 13 feet 6 inches, length of 43 feet and can support loads of 60 tons. Experimental scissors bridge which is carried and launched by a modified turretless tank, left background, is shown being unfurled, right. Made of aluminum, the scissors bridge is designed to support 60-ton loads. It is presently being tested at Fort Belvoir

by writing the society at 920 Midland Bldg., Cleveland 15, Ohio. Deadline for the contest is November 1, 1954.

Precise Gyroscope Can Measure City Block on Moon

Capable of measuring such minute angles as would be required to measure the width of a city block on the moon from a point on the earth, a new type gyroscope was recently developed for the U. S. Air Force by Minneapolis-Honeywell. Weighing less than 3 pounds, the instrument will be used for automatic flight control systems for supersonic aircraft and guided missiles as well as bombing and gun fire control. Other uses range from ocean-going vessels to 60-ton tanks.

Said to be hundreds of times more accurate than conventional gyros, it is reported capable of detecting an angle smaller than 1/36,000 of 1 degree of arc. These minute measurements are transmitted electrically to servo motors or other components to adjust the operation of such systems automatically.

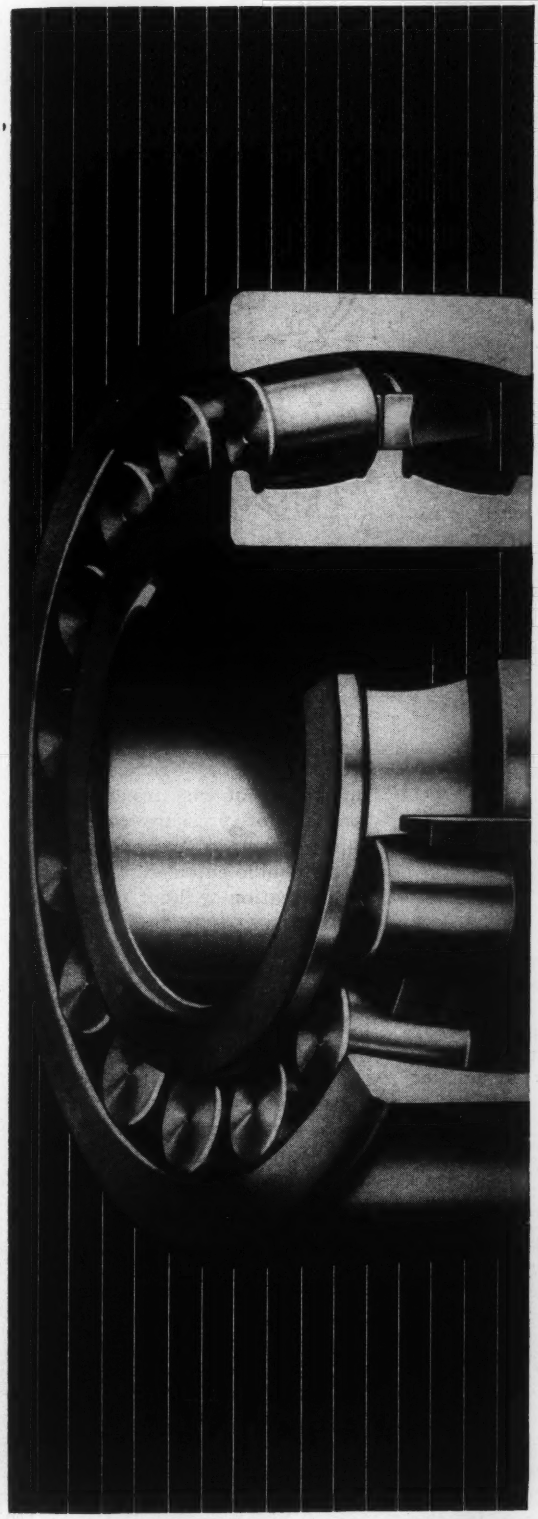
Friction among the gyroscope's moving parts has been cut to almost zero by floating the jewel-mounted spin mechanism in a specially developed oily fluid; thus the gyroscope is called a "floated" type. Speed of the spin motor is controlled by a crystal oscillator accurate to one part in one million.

Presently being mass produced, the unit is said to be so rugged that a demonstration model was used to drive nails through a board without affecting the instrument in any way.

Fractional Horsepower Motor Department of General Electric has been discontinued and four new departments have been organized to take over its operations. The four new departments and their managers are: General Purpose Component Motor Department, Lisle D. Hodell; Hermetic Motor Department, Ab Martin; Appliance Motor Department, Carl W. Moeller; and Specialty Component Motor Department, Jack J. Clarkson. All managers will have headquarters in Fort Wayne, Ind. except Mr. Moeller who will be located in DeKalb, Ill.

Gage Measures Thrust Bearing Wear

Failure or wear of thrust bearings in heavy rotating machinery such as turbines may be detected by means of a noncontacting distance gage developed at the National Bureau of Standards. Based on the mutual inductance principle, the device consists of two small coils wound on a dielectric core mounted on the machine frame near the shaft. Regulated rf voltage is applied to the primary coil inducing a voltage in the secondary, and as part of the electrical system, a brass disk mounted on the shaft changes the mutual inductance between the two windings by its motion toward or away from the core. Output of the secondary, which is dependent upon the spacing of the disk from the core, is measured by a suitably calibrated meter indicating the shaft position



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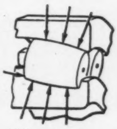
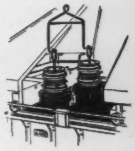
TORRINGTON

Spherical Roller Bearings

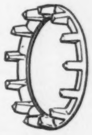
Uniform, close control of precision-ground contact surfaces—for even load distribution and maximum bearing life.



Accurate geometrical conformity between races and rollers—for ultimate load carrying capacity and performance.

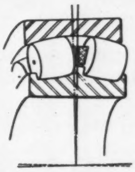


Races and rollers heat treated according to the most advanced metallurgical procedures—for maximum durability.

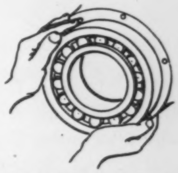


Individual one-piece cage for each path of rollers—assures freedom of operation.

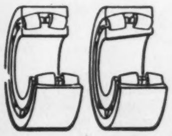
Integral flange on inner race—to give radial stability and positioning for thrust loads—both essential to satisfactory performance.



Self-aligning—for continuous, free-rolling service under shock loads and at sustained speeds.



Unit assembly—for easy, economical handling.



Available from stock with either straight or tapered bore—for shaft or adapter mounting.

These are advantages that give you long, efficient, low-maintenance service in the toughest heavy-duty application.* To get maximum value for your bearing dollar, *specify TORRINGTON Spherical Roller Bearings.

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TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

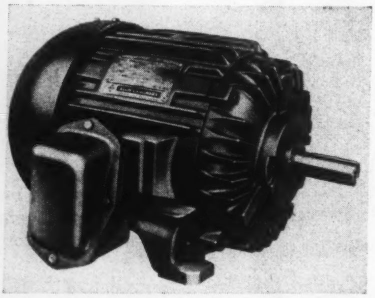
SEVENTY DAYS LIFE of the solid titanium trim of this control valve is considered normal when operating with highly corrosive fluid under high pressure. Made by Minneapolis-Honeywell at a cost of $10,000, it is of the diaphragm type using silver to line the inlet bore for increased life. One year is said to be added to the life of the valve body by making the bore ½-inch smaller than usual, since corrosion is expected to take place at the rate of about 0.001-inch per day

relative to the frame. Range of the instrument is from 50 microinches to several inches with an accuracy of 3 per cent. Its use enables full life of bearings to be realized without the necessity for premature replacements as well as providing warning of impending failures.

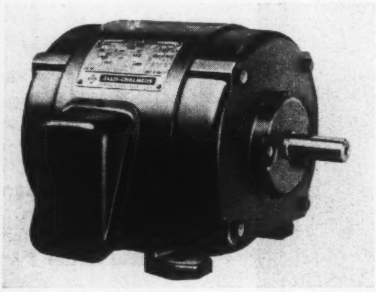
Radioactive iron ore, 76 tons of it, was recently used to determine feasibility of using fine iron powders as part of a blast furnace charge. Ordinarily the powders are sintered into lumps before being charged into the furnace to prevent their being blown out. Results of the experiment showed about 60 per cent of the powders were retained during the process. Although this amount was higher than the Ford Motor Co. researchers who conducted the experiment expected, it is not high enough to make use of the unsintered powders practicable.

More Power In Equal Space

Built to the newly established NEMA Standards, Allis-Chalmers new line of ac squirrel cage induction motors in frame sizes 326 and smaller were shown recently. At present, production is under way on NEMA frame sizes 182 and 184. Larger frame sizes are expected to become available at five-month intervals.

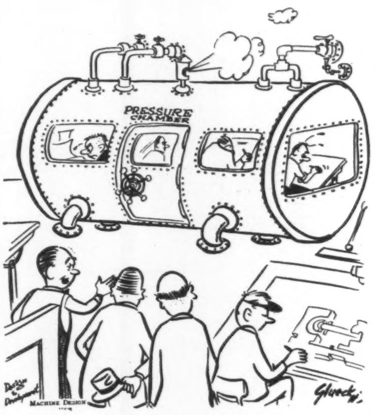


Redesigned according to the latest NEMA Standards, the 1½-horsepower, 220/440-volt, 3-horsepower, above, and the 5-horsepower, 220/440-volt, 3-phase motor, below, offer rated horsepower in smaller frame sizes



Technological advances in the development and application of new metals, insulation materials and heat transfer methods have made possible the rerating which results in making more horsepower available in the same frame size. Appearance of the new Allis-Chalmers motors is similar to present design. Frames and end shields are of cast iron, while rotors are of pressure cast aluminum. Bearings are grease lubricated, double shielded, and capable of lubrication without dismantling the motor.

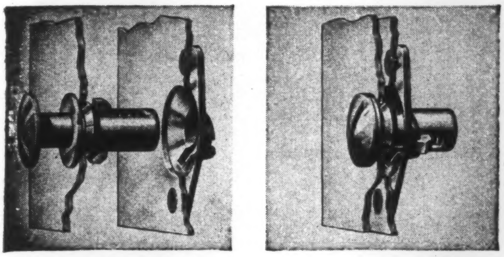
Greater protection of the intake openings in the open type motors is afforded by the new design. Intakes are located in the bottom half of the end shield and high enough above the base to minimize the possibility of incoming air sweeping in dust or lint from the floor or base. All the company's new design totally enclosed motors are fan cooled.



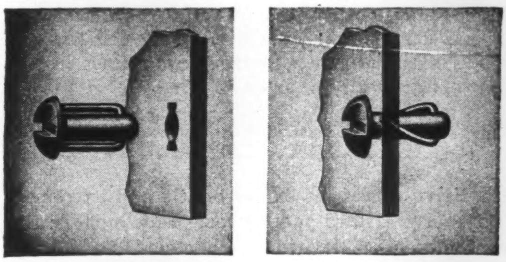
"That's where we handle the rush jobs."

Oil hydraulics as a means of power or control of machine tools is becoming increasingly important especially because of the increased use of automation, according to Dr. Victor L. Streeter of Illinois Institute of Technology. To meet the need for more education and research in this field, a new laboratory has been completed at IIT donated by companies in the hydraulics field and is said to be the most complete such facility in the United States. Offering a broad educational program, the labora-

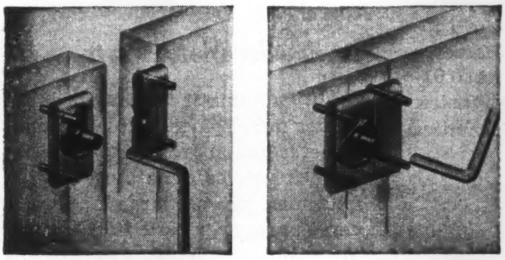
3 ways to save on assembly costs



QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.



SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. SPRING-LOCK is now available in high-impact plastic. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.



ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals; recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

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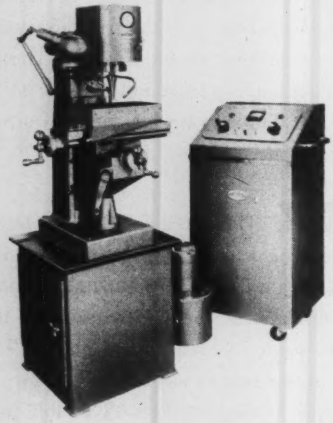
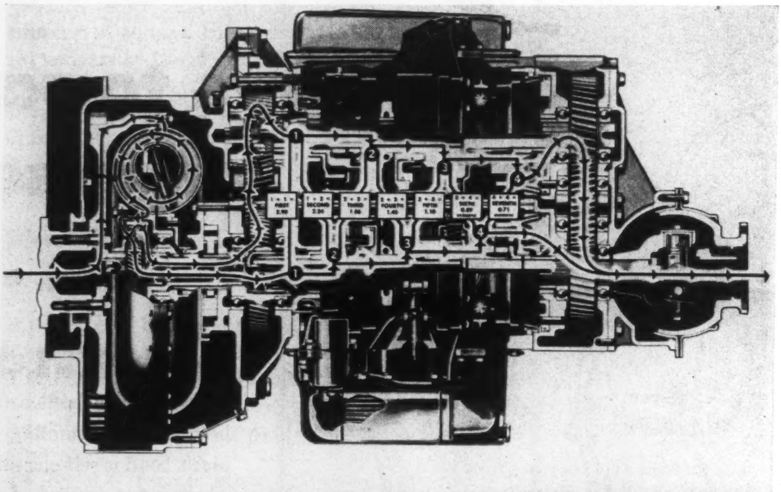
tory is equipped for study up to graduate level research.

New Machine In Ultrasonic Cutting Field

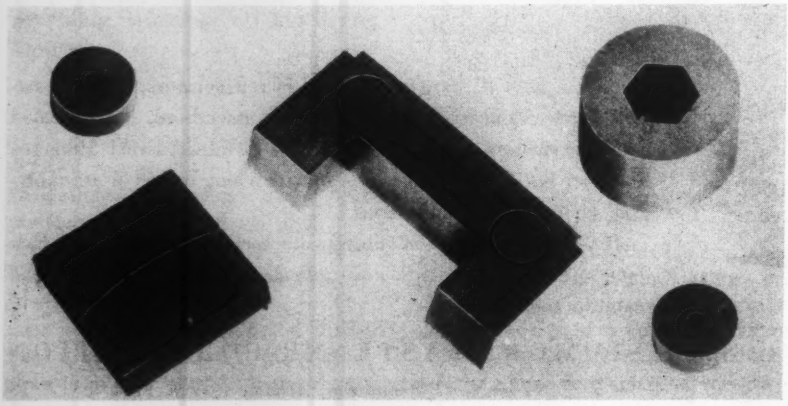
Ceramics, glass, precious stones, carbides, tool steels, and fused or sintered materials can be drilled and cut using soft, easily machined tools, inexpensive abrasives and vibration as high as 25,000 cycles per second with a recently announced machine produced by Raytheon Mfg. Co. Machines of this type have also been produced for some time by Sheffield Corp. Magnetostrictive transducers, which convert electrical vibration to mechanical vibration, drive the abrasive particles at extremely high speeds against the work surfaces to perform the cutting. Dimensional accuracy can be held to tolerances of plus or minus 0.001-inch. Cutting speeds vary; a typical rate for a ⅜-inch diameter hole in tungsten carbide is 0.01-inch per minute. Through holes, blind holes and contoured cavities can be cut in brittle and extremely hard substances. Fine surface finishes are also produced.





HEAVY-DUTY TRUCK transmission built by General Motors consists of two Hydra-Matic units, one mounted above the other. Providing seven forward speeds and one reverse, the automatic shift is expected to greatly reduce driver fatigue resulting from gear shifting. Designed for use with 150-horsepower gas and diesel power plants, the unit will eventually be designed for engines in the 175 to 225-horsepower range

Typical parts machined by ultrasonic cutting machines. Exterior surfaces can also be cut with these machines



New Press For Powder Metal Parts

Fully automatic molding of large powder metal parts up to 12 inches diameter and approximately 3 inches thick will be done by a 300-ton hydraulic press, largest powder metal press ever built in this country. Molds having a maximum depth of fill of 8 inches can be handled conveniently. First press of the new series has just been shipped by the builder, F. J. Stokes Machine Co., to a leading U. S. manufacturer of aircraft brakes.

Control over the pressing cycle is completely automatic. Rate of production can be adjusted precisely to the thickness of the parts being compacted. For the thickest parts, operation is at the rate of four strokes per minute; with thinner parts, the rate increases to a maximum of ten strokes per min-

HERE ARE YOUR KEYS TO DESIGNING FOR LOW-COST PRODUCTION–

See for yourself

HOW "PRODUCTION PROCESSES" CAN HELP YOU SOLVE DESIGN-PRODUCTION PROBLEMS

PRODUCTION PROCESSES
THEIR INFLUENCE ON DESIGN
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THEIR INFLUENCE ON DESIGN

VOLS. I & II

By Roger W. Bolz

COVERS THESE 9 BIG PRODUCTION AREAS

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- Metal Removal Methods
- Metal Forming Methods
- Metal Working and Forging Methods
- Metal Deposition Methods

Vol. II

- Casting Methods
- Molding Methods
- Fabricating Methods
- Treating Methods

The "keys" are two volumes on how you can bring the shop into your design department . . . on how you can actually plan your designs for smoother production. "Production Processes", with 924 pages of authentic text, charts and illustrations covering 56 different shop processes, can help correct your design-production mishaps . . . correct them while the designs are still in the drawing board stage! Here is production know-how in advance and in place of trial and error on the line. Here in two volumes is what design and production men all over the country regard as their "keys" to designing for low-cost production. You get usable information on how to select materials . . . you see the surface finishes produced by the various processes . . . and you find explained the practical tolerances which can be held while using these processes.

Here is a really comprehensive treatment of the production approach to design. See for yourself. Use the handy order form below and get your set now.

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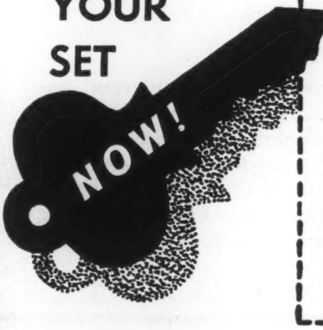

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ute.

The press is a double-acting design, with each of the rams independent both as to its speed of movement and as to the pressure exerted. To achieve this, each ram has its own hydraulic pump and volume control. A pair of threaded stops accurately control the final spacing between upper and lower platens and hence between upper and lower punches. Easy adjustment of these stops means that the thickness and density of the finished part can be precisely controlled at all times. A shuttle-type feed shoe with hardened top and bottom surfaces to resist wear provides accurate, positive filling of the mold without any spillage of material.

Twin ejection cylinders deliver the full pressure of the hydraulic system for positive, dependable ejection of the finished piece from the mold after compacting.

The control panel, conveniently located at the front corner of the press, allows instantaneous conversion from fully-automatic to semiautomatic or manual operation at any point in the cycle. Safety switches prevent accidents in case of an unintentional change in the position of the control levers.

Sound slide films prepared for design engineers and engineering students are available through Allis-Chalmers General Machinery Div. district offices. On the subject of V-belt drives, the films are titled "In Every V-Belt Drive," "For Better Driving," and "Selecting a Drive." Running time of the films is approximately 20 minutes each.

Meetings and Expositions

May 17-20—

Basic Materials Exposition. Second exposition and conference to be held at the International Amphitheatre, Chicago, Ill. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 26-27—

American Iron & Steel Institute. Annual meeting to be held at the Waldorf-Astoria Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 350 Fifth Ave., New York, N. Y.

June 6-9—

American Gear Manufacturers Association. Annual meeting to be held at the Homestead Hotel, Hot Springs, Va. J. C. Sears, One Thomas Circle, Washington 5, D. C., is executive secretary.

June 7-10—

Society of the Plastics Industry. National Plastics Exposition to be held at the Public Auditorium, Cleveland, O. William T. Cruse, 67 West 44th St., New York 36, N. Y., is executive vice president.

June 9-11—

American Society for Quality Control. Annual convention and exhibit to be held at Hotel Jefferson, St. Louis, Mo. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

June 13-18—

American Society for Testing Materials. Annual meeting and exhibit to be held at Hotels Sherman and Morrison, Chicago, Ill. Robert J. Painter, 1918 Race St., Philadelphia 3, Pa., is executive secretary.

June 14-15—

Malleable Founders' Society. Annual meeting to be held at the Seigniory Club, Province of Quebec, Canada. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

June 14-17—

American Society of Mechanical Engineers. Oil and Gas Power conference to be held at Hotel Muehlebach, Kansas City, Mo. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

June 20-24—

American Society of Mechanical Engineers. Semiannual meeting to be held at the William Penn Hotel, Pittsburgh, Pa. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

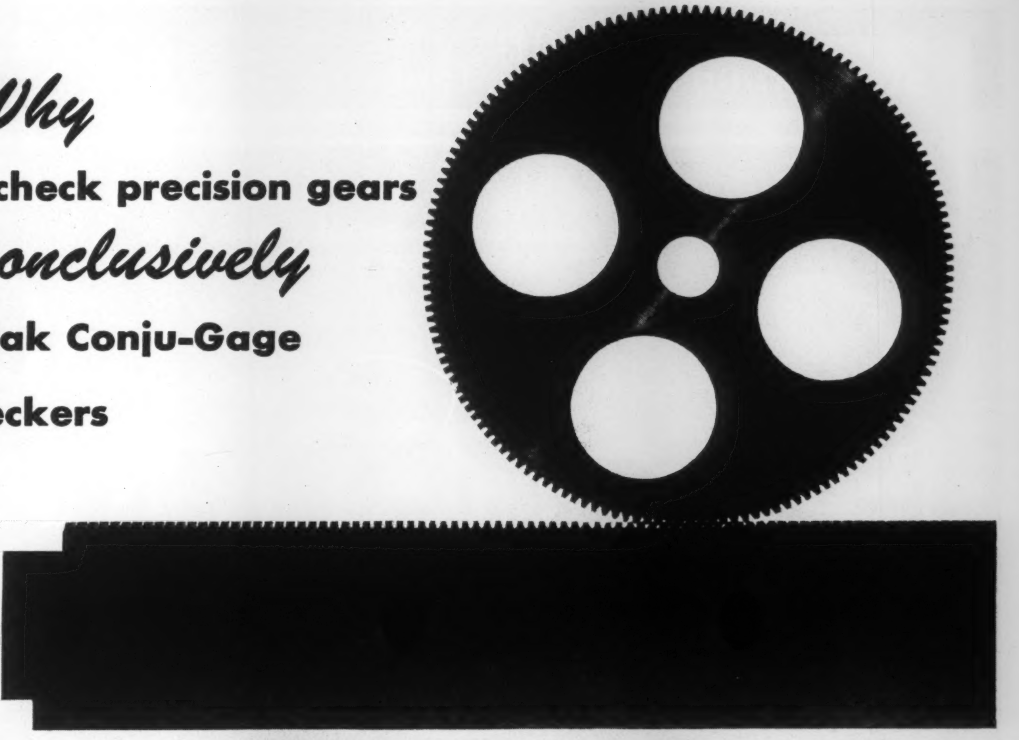
June 21-23—

American Management Association. General management conference to be held at Hotel Statler, New York, N. Y. James O. Rice, 330 West 42nd St., is vice president-secretary.

July 12-15—

American Electroplaters' Society. Annual convention to be held at Hotel Statler, New York, N. Y. Additional information may be obtained from society headquarters, 445 Broad St., Newark 2, N. J.

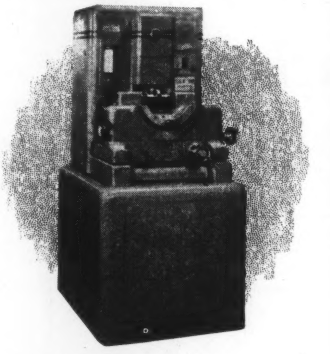
Here's *Why* you can check precision gears *more conclusively* with Kodak Conju-Gage Gear Checkers



Why the composite check

Errors in gears seldom occur individually—they're usually combinations of as many as six types of errors. The practical way to test gears for these errors is to test them in action through the composite check recommended in the new American Standard (AGMA 236.02; ASA B6.11-1951).

This check measures gear errors as variations in center distance when the gear is rotated in contact with a master of known accuracy. Since this variation is the sum of errors in both gear and master, the degree of precision measurable depends on the precision of the master.



The Kodak Conju-Gage Gear Checker automatically records the composite effects of runout, base pitch error, tooth thickness variations, profile error, lead error, and lateral runout. Illustrated is the Kodak Conju-Gage Gear Checker, Model 4U, for gears up to 4⅛" pitch diameter. Larger and smaller models are also available.

Why the Conju-Gage Gear Checker

Kodak Conju-Gage Gear Checkers use a master of exceptional accuracy, the Kodak Conju-Gage Worm Section. These Worm Sections are generated by the continuous action of a thread grinder under control of a precision lead screw—circular pitch error and tooth thickness variations cannot be introduced by defects in an intermittent indexing mechanism. This means a more accurate gaging element, less chance that error in the master may coincide with a tolerable error in the gear to result in a needless rejection. Less chance, too, that an error in the master may subtract from an intolerable error in the gear, passing a gear that will fail in use.

By passing each right gear, rejecting each wrong gear, the Kodak Conju-Gage Gear Checker helps you reduce costs while maintaining highest precision. For the full story of this and other economies achieved by Conju-Gage instrumentation, send for the booklet, "Kodak Conju-Gage Gear Testing Principle." Write to:

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. . . a new way to check gear precision in action

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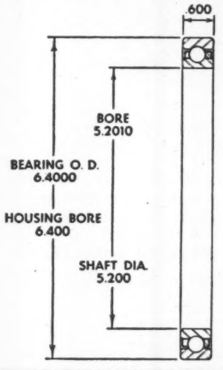
Kaydon special radial ball bearings
5.200″ x 6.400″ x 0.600″

Special radial ball bearings—industrial jewels produced by Kaydon

Unusual thin-section, high-precision bearings like these are standard products of the **KAYDON** Engineering Corporation. **KAYDON** designers and engineers have come to regard "near impossible" assignments as everyday routine.

That's why more and more manufacturers call in **KAYDON** on problems involving special bearings. They've happily found . . . that to build the special bearings they need . . . **KAYDON** has the unmatched experience and the facilities necessary to handle the job on an economical basis.

Details of thin section bearing shown above—



KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

1. Stacked Retaining Rings

Industrial Retaining Ring Co.—Retaining rings stacked on metal rods make assembly faster and easier, according to 4-page illustrated bulletin. "One-at-a-time" dispensing unit which consists of special base and application tool provided free with initial order is also covered. Size and price data are also given.

2. Case Hardening Steels

Jones & Laughlin Steel Corp.—Ten grades of Jalcase cold finished case hardening steels are described in 14-page illustrated booklet. Properties of the open hearth steel include easy machinability, minimum distortion, fast heat treatment, high wear resistance and good mechanical properties.

3. Stainless in Paper Industry

Allegheny Ludlum Steel Corp.—36-page well-illustrated brochure SS27 describes the use of stainless steel in the pulp and paper industries and gives detailed information on technology of Allegheny metal. Special stainless finder for use in paper industry analyzes types of stainless available on basis of comparative properties.

4. Vibration Isolation

Korfund Co.—Uses of compressed corkboard in isolating vibration caused by rotating or reciprocating machinery are covered in illustrated data sheet VC-501. Deflection curves, physical properties and installation methods are pictured and described and applications are indicated.

5. Electronic Recording Equipment

Edin Co., Inc.—Oscillograph recorder systems, amplifiers, galvanometers, recorders, chart recording paper, pens and ink are among the electronic data recording equipment and accessories covered in 4-page illustrated condensed catalog G.C. 3. Essential comparitive data and price information are provided.

6. Centralized Lubrication

Johnston Equipment & Supply Co.—Technical data on various models of centralized oil lubricators are found in the 20 pages of illustrated bulletin "Central Lubrication." Operation, installation and maintenance information are included, along with fittings and accessories data.

7. Magnetic Pumps

Fostoria Pressed Steel Corp.—Rotating magnetic field is employed by the Dynapump to drive the impeller. Motor and pump are in one sealed unit which will handle water, solvents, refrigerants, corrosive fluids, beverages, heat transfer fluids, petroleum products, etc. Four-page illustrated form P-11-53 describes the pump.

8. Self-Aligning Bearings

U. S. Bearing Corp., Halfco Div.—Information on complete line of standard Halfco two-piece, integral high-load, self-aligning bearings with material finish and heat treating specifications is contained in this 7-page looseleaf catalog. Ball and race maintain a contact area of more than 90 per cent. Stainless steel outer races have 160,000 to 180,000 psi tensile strength.

9. Unalloyed Titanium

Mallory-Sharon Titanium Corp.—Properties of commercially pure unalloyed titanium are given in 4-page bulletin. Recommended techniques for fabricating and forming titanium sheet are presented. Material is produced by a double melting process in which carbon content can be exactly controlled.

10. Lettering Device

Varigraph Co.—One templet used with the Varigraph precision lettering machines makes it possible for draftsman to produce over 500 various forms of the one letter style, variations being in height and width, solid or outline form. It does not ride over work to cause smearing. Twenty-page illustrated brochure shows extensive "library" of type faces and symbols available.

11. Production Facilities

I-T-E Circuit Breaker Co.—Technology, ability and facilities of the Special Products Division of this company are described in 20-page illustrated brochure SP100. Discussed are part company plays in manufacture of radar antenna systems, jet engines, thermodynamic equipment, guided missiles and titanium. New operational techniques and processes, including welding, forging, forming and spinning are covered.

12. Alternating Current Motors

Brook Motor Corp.—Chart of electrical and mechanical features of standard and special British-built alternating current motors is included in this 6-page illustrated folder to facilitate selection of the right motor for the job. Line includes 1 to 50 hp open dripproof, splashproof, totally enclosed nonventilated and totally enclosed externally fan-cooled motors. All have standard American threads, nuts and bearings.

13. Power Transmission Equipment

Lovejoy Flexible Coupling Co.—Engineering drawings, ratings and dimensions and representative applications for line of variable speed pulleys, wide V-belts, sheaves, motor bases, countershafts and Select-O-Speed transmissions are found in 24-page illustrated catalog 118.

14. Beryllium Copper Tubing

Superior Tube Corp.—Properties, applications and advantages of seamless and Weldrawn beryllium copper tubing are completely covered in data memorandum No. 7-2. Mechanical and physical properties, heat treating procedures, welding and brazing methods, pickling solutions, corrosion resistance tables, standard production limit tables and tubing tolerances are all given, amongst other information.

USE THE POSTAGE FREE CARDS BELOW for copies of anything listed on this or following helpful literature pages—or for further information on any items in the new parts section or the engineering department equipment section which you'll find on the next several pages.

For additional information on anything advertised in this issue, use the yellow cards in the front section of this magazine.

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15. Air Gage Cartridges

Sheffield Corp.—Plunjet gaging cartridges, called the gage head of 10,000 uses, are subject of 24-page illustrated bulletin 126-53. Devices are used with column and dial Precisionaire air gages for gaging and machine control applications. Many application data are included.

16. Centrifugally Cast Products

Electric Steel Foundry Co.—Applications and properties of ESCO Spuncast centrifugally cast heavy wall cylindrical stock, tubes and IPS pipe are illustrated in descriptive booklet 184-A of 12 pages. It relates how costs can be cut through use of the material, offered in various stainless analyses.

17. Carbon Steel Specifications

Peter A. Frasse & Co.—Chemical analysis requirements for each of 60 military, army, navy, aeronautical and federal specifications are listed on this file-size cardboard chart. Also included are specified forms and nearest corresponding SAE, AISI and AMS type numbers.

18. Fiberglas Insulation

Owens-Corning Fiberglas Corp.—8-page illustrated manual gives design data relative to heat, cold and sound control in appliances using Fiberglas. Manual, designated EA6.C2, shows different available types and ties in product sales promotion.

19. Production Facilities

Reynolds Metals Co.—24-page well-illustrated bulletin covers contract production facilities in aluminum fabrication. Complete service is pictured from mine to finished parts. Production equipment is listed and described.

20. Pressure-Tight Castings

Meehanite Metal Corp.—Sixty-four illustrations of specific industrial applications of Meehanite castings where specifications demanded absolute density, uniformity and resistance to various pressure ranges are found in 48-page bulletin No. 43. "Meehanite Castings for Pressure Tightness" provides some engineering property charts and pressure casting design suggestions.

21. Anticorrosion Coating

Industrial Metal Protectives, Inc.—A corrosion and abrasion resistant treatment for iron, steel and aluminum products, Zinclate No. 100 is covered in available illustrated bulletin. It can be flow-coated, dipped, sprayed or brushed on.

22. Steel Pipe & Tubing

Babcock & Wilcox Co., Tubular Products Div.—Alloy tubing steel called Croloy 9M, used in elevated temperature service, is discussed in 4-page Technical Data Card 151. Material has high corrosion resistance which gives it a life of 40,000 to 100,000 stream hours or more. Properties are given.

23. Dry Film Lubrication

Electrofilm, Inc.—Answers for solution of difficult lubrication problems due to extreme heat, excessive cold, inaccessibility, high speeds or loads, galling, seizing and excessive wear are found in this file folder on Electrofilm dry film lubricants.

24. Aluminum Fabrication

Falstrom Co.—Bulletin 140 briefly describes company facilities for aluminum fabrication. Products are listed, and some are illustrated.

25. Tetrafluoroethylene Resin Finishes

E. I. du Pont de Nemours & Co.—Teflon tetrafluoroethylene resin finishes detailed in fourth edition of 12-page bulletin No. 1 have antisticking properties, high heat stability, low coefficient of friction and good corrosion resistance against many chemical expo
Extensive data are given on these properti
methods of application, fusing operation
precautions and handling.

26. Alloy Steel

International Nickel Co.—Sixteen charts
tained in 6-page bulletin NS-1 present
of information on composition, heat treat
transformation characteristics and mech
properties of standard AISI and SAE
chromium-molybdenum steels.

27. Metallizing

Metallizing Engineering Co. — Metal
process is subject of 8-page bulletin 51A
discusses the characteristics of sprayed
describes where metallizing is used, its
vantages and limitations. Some of the
illustrated include repair of worn crank
pump packing sleeves, press rams,
rotors and stators, rolls, motor shafts,
cylinders.

28. O-Rings, Hydraulic Packings

Stillman Rubber Co.—Facilities and
of this company are described in 24-pag
lustrated catalog. Products comprise
range of custom molded parts
thermoplastic and synthetic rubber
Teflon O-rings and back-up rings and
lic packings to commercial and gover
specifications. Data covers installation,
moving or static seals and dimensions.

29. Rotating Piston Pumps, Motors

Oliver Iron & Steel Corp., Berry
Rotating piston hydraulic pumps, motors
transmissions are described as to
operation and application in 8-page illus
catalog 5310. Three series of pumps
specified with deliveries ranging from
at 2000 psi to 240 gpm at 500 psi.

30. Alloy Steel Screws

Strong, Carlisle & Hammond Co.,
Screw Div.—"Better Fastening for
Products" is 36-page catalog compiled
engineering and selection of fasteners
products of industry. Complete data on
cal characteristics and ASA dimension
ards are included. Charts for standard
and list prices make information easy to

31. Rubber Parts

Tyer Rubber Co.—"Molded and Extru
Parts of Natural and Synthetic Rubber"
subject of 8-page illustrated catalog IP
It shows the various types of parts made
company's Industrial Division. Uses and
dividual specifications of each are given
charts of rubber and synthetic rubber
pounds and their properties for autom
and aeronautical applications are included.

32. Teflon Products

Ethylene Chemical Corp.—Extensive line
Teflon products described in 8-page catal
2427 includes high tensile molded rods,
and sheets; extruded rod and tubing;
tronisized rod; custom moldings; machi
parts; shaved tape, etc. Techniques for
chining are described, and applications
properties are listed.

33. Cast Bronze & Copper

American Brake Shoe Co., National Bear
Div.—24-page illustrated booklet presents
division's "Cast Bronze and Copper Prod
for General Industry." Sections deal
firm's research, process, engineering and
duction facilities, and alloy chart lists
position, analyses, properties and speci
tions of copper, babbitt, bronze and alum
alloys.

34. Cast Stainless Steels

Cooper Alloy Foundry Co.—Chemical
ses, physical properties and recommen
plications for 28 different grades
stainless steel are given in 4-page
chart. Also included are ACI, AISI,
ASTN and general type designations
treatment, weldability and machinability

(Continued on Page 214)

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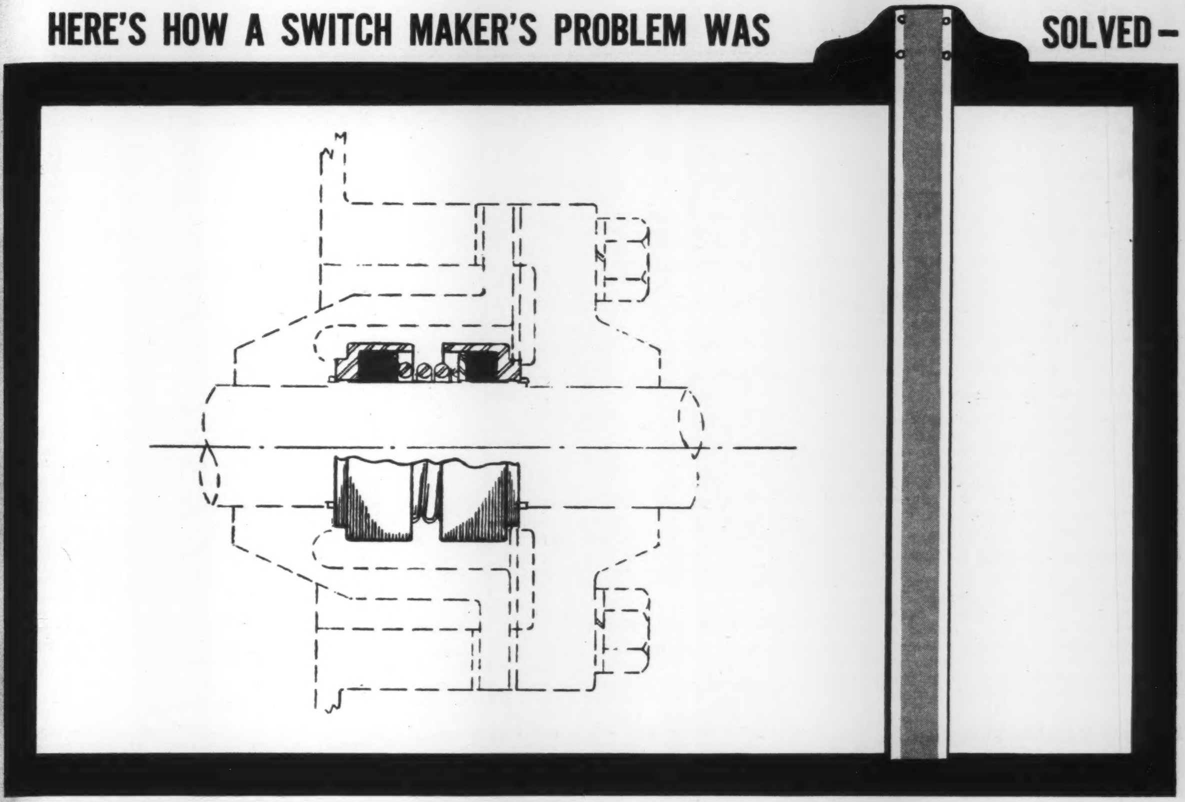

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Even after complete submersion for protracted periods, or when exposed to weather extremes, heavy duty switches must be in perfect condition to make an alternate source of power immediately available the instant cable trouble occurs. Any Seal failure at the point where the operating shaft extends through the wall of the hermetically sealed tank might be serious. To assure the *Shaft-Sealing Certainty* they must have, ROTARY SEALS have been the choice of leading switch makers for many years.

Since no two designs pose precisely the same problem, ROTARY SEALS are tailor-made for each specific case, with just the right adaptation of the famous original ROTARY SEAL patented sealing principle to do the most efficient job possible. This principle is clearly explained and illustrated in our booklet, *"Sealing with Certainty"*, a copy of which is yours for the asking.

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Manufacturers in many industries assure the long-run user satisfaction which builds more sales by *Sealing with Certainty* with individually designed Rotary Seals. We believe Rotary Seal engineers can save *you* time and money, too—call them in at the drawing-board stage!

THE ROTARY SEAL COMPANY

mechanical seals for rotating shafts

Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

Helpful Literature

(Continued from Page 212)

35. Industrial Cork Products

Dodge Cork Co.—Physical characteristics and uses for both natural cork and cork compositions are given in 4-page bulletin S-54. Government and SAE-ASTM equivalents of popular cork compositions, as well as sheet sizes and thicknesses, are listed.

36. Sleeve Bearings

O & S Bearing Co.—The O & S sleeve bearing designed for axial, radial and corner load receives description in 4-page bulletin 153. General construction is of lubricant-impregnated fabric and formed steel shell. Nylon is combined with fabric and helps take up shock loads.

37. Wire-and-Nylon Rope

Rochester Ropes, Inc.—Wirelon ropes, described and illustrated in 16-page wire-bound booklet, are made of high tensile steel strands covered with a durable coating of nylon. Steel core has tensile strength of 250,000 psi. Range of sizes, strengths and other physical characteristics are available.

38. Industrial Plastics

Joseph T. Ryerson & Son, Inc.—Data on manufacture, grades, properties, fabrication and use of laminated plastic sheets, tubes, rods and special shapes are offered in 16-page illustrated bulletin S-1-20-4. Piece also has information on decorative plastic sheets and includes performance records of plastic bearings in industrial and marine service.

39. Small Quantity Stampings

Federal Tool & Mfg. Co.—Small quantity die and stamping costs for runs up to 1000 pieces are covered in 4-page illustrated bulletin. Specifications for maximum blank size, thickness and pressures are given. Samples produced by company's methods are available with bulletin.

40. Stainless Steel Selector

Crucible Steel Co. of America—Slide rule-like chart quickly determines what type of stainless steel should be used for about 95 of operations requiring stainless. Front compares physical, mechanical and elevated temperature properties, and reverse side gives important characteristics of stainless.

41. Thermoplastic Material

Eastman Chemical Products, Inc.—A brief discussion of Tenite—what it is, its properties and uses and the methods by which it is formed into finished products— is contained in 16-page booklet "Tenite an Eastman Plastic."

42. Induction Motors

Electric Products Co.—Heavy duty line of protected induction motors with standard NEMA frame sizes have their construction features outlined in 4-page illustrated bulletin 37-205. Motors are completely "weatherproofed" and are offered in ratings from ½ to 125 hp for installation anywhere.

43. Tubing & Moldings

Acme Tube, Inc.—30-page illustrated catalog is comprehensive guide to selection of roll formed metal tubing and molding, intended to aid the designer in his task of creating more functional products. Roll forming method is described and each of the basic types of tube, channel, angle and molding is classified and illustrated.

44. Polyethylene

Bakelite Co.—Information about molding, extruding and other ways to use Bakelite polyethylene, as well as properties of resins, is presented in 8-page folder GA. Principle uses in packaging, wire covering, housewares, pipe and industrial products are shown. Tables list properties of various resins available in commercial and experimental quantities.

45. Instruments

Daystrom Inc., Instrument Div.—32-page illustrated brochure shows plant and personnel dedicated to manufacture of precision electrical and mechanical instruments and systems. Laboratory, pilot plant and production units are individually considered.

46. Control Relay Booklet

Westinghouse Electric Corp. — Application and design information on the type N control relay are given in booklet B-5817. Remote control unit has a 10-amp open rating, up to 600 v and 6 poles and is available in any normally open-normally closed combination. Illustrations show construction and wiring circuits.

47. Plastics

Emerson & Cuming, Inc.—Series of bulletins describe line of casting resins, plastic foam and other radio frequency and microwave insulation materials. Detailed data are given on physical and electrical properties and on applications.

48. Quick Couplings

Breco Mfg. Co.—Pushomatic quick couplings for any air, hydraulic or fluid handling applications are featured in 2-page descriptive bulletin 54-1. Couplings are available with end connections from ⅛ to 3 in. male pipe thread, female pipe thread and hose stems.

49. Sheaves

Browning Mfg. Co. — 24-page illustrated pocket-size booklet on Gripbelt sheaves with malleable split taper compression bushings points up features and advantages of the complete line. Design is considered, manufacturing details shown and size range available given.

50. Scraper Rings

Gadgets, Inc.—Hydro-Wype scraper rings for use in hydraulic equipment are covered in file-type loose-leaf folder. Design to MIL and other specifications is shown. Data include engineering drawings, size availability and construction details.

51. Control Components

General Electric Co.—16-page well-illustrated bulletin GEA-5779B covers such control components as oil-tight pushbuttons, indicating lights, selector switches and other accessories. Drawings, dimensions and applications are given.

52. Directional Valves

Hydraulic Press Mfg. Co., Hydraulic Power Div.—In 64 well-illustrated pages of catalog 841, over 30 directional and functional valves in the 3000-psi class are described, illustrated and fully specified. Units are gasket mounted and designed for oil hydraulic service.

53. Wire Cloth, Perforated Metals

Pittsfield Products, Inc.—Products fabricated from wire cloth and perforated metals are shown in 8-page brochure. These include strainers, screens and filters with fittings attached; wire cloth stampings; crimped wire cloth; wire cloth soldered units; welded and soldered perforated metal parts.

54. Flexible Metal Hose

DK Mfg. Co., Cobra Metal Hose Div.—Suitable in high pressure, high temperature and highly corrosive conditions, Cobra seamless monel and nickel flexible hose is featured in 8-page catalog 100 in addition to stainless steel, bronze and steel types. Application data and specifications are provided.

55. Glass-To-Steel Terminals

Fusite Corp.—20-page catalog describes complete line of hermetically sealed glass-to-steel terminals. Ten groups detailed include such variations as miniature singles, standard size singles, stand-offs, threaded bushing, multiples, miniature multiples, plug-ins and crystal can headers. Flange and panel treatments are also described.

56. Mold Release Agents

Linde Air Products Co.—Designed for use in the shell molding process, three silicone release agents are covered in 8-page illustrated bulletin F-8271A. Properties and use instructions are covered in some detail.

57. Casting Impregnation

Polyplastex International, Inc.—8-page illustrated bulletin on casting impregnation to increase pressure tightness and density covers reasons for using process, its possibilities in manufacture and savings possible through reduction of internal corrosion.

58. Revolving Joints

Rotherm Engineering Co.—12-page illustrated catalog No. 11 covers revolving joints for making connections to rolls and similar equipment. Wide variety of units are described as available for steam, air and hydraulic service. Design features are shown.

59. Welding Electrodes

Ampco Metal, Inc.—Use of various types of bronze welding electrodes in reclaiming industrial equipment and possible cost savings and economies are pointed up in 4-page illustrated catalog W-25. Metal to metal bearing problems, overlaying for corrosion resistance and hard facing are covered.

60. Flexible Shaft Valving

Stow Mfg. Co.—16-page well-illustrated bulletin 528 covers design considerations of remote control of valves and other equipment actuated by rotating shafts using flexible shafting. Selection of components is covered in detail, and installation procedures are shown. Range of available equipment is also described.

61. Rhodium Electroplating

Baker & Co.—"Electroplating with Rhodium" is title of 24-page illustrated manual. Complete data and directions are given on the process, for use as a decorative finish, in the electrical and electronic industries, for making reflectors and mirrors and for general purpose work.

62. Subminiature Connectors

DeJur-Amsco Corp., Electronic Sales Div.—Series FHL 2-page illustrated bulletin contains information on subminiature single pin connector and on series C-20 high voltage single contact cable and panel connectors. Dimensions, ratings and materials available are described.

63. Time Delay Relay

Elastic Stop Nut Corp. of America, AGA Div.—Model SF hermetically sealed time delay relay is covered in 4-page illustrated bulletin SR-5. Unit can be externally adjusted for delays ranging from 1.030 to 120 seconds and meets MIL specifications for vibration, shock, temperature resistance, etc.

64. Investment Castings

Vascoloy-Ramet Corp. — 8-page illustrated brochure VR-470 covers investment castings and their use in producing small parts with intricate forms and wear, corrosion, heat and oxidation resistance. Investment castings of parts requiring nonmachinable materials are also shown, produced to finished tolerances

TO GET ALL THE PERFORMANCE DESIGNED INTO YOUR PRODUCT

Choose *Century* MOTORS

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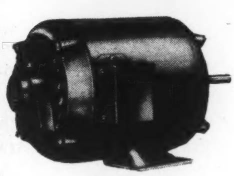


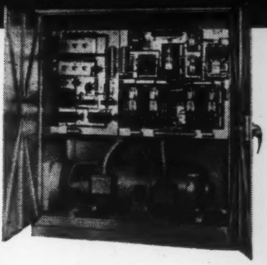
SINGLE PHASE:

Split Phase Induction—⅛, ¼, ⅓ H. P.

Capacitor—⅛ to 20 H. P.
Repulsion start, brush lifting, induction—½ to 7½ H. P.

Write for Bulletin Nos.:

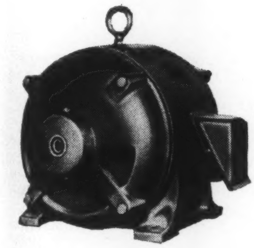
Split Phase	1-5P1
Capacitor	1-1P3
Repulsion Start	2-1P1



SELECTIVE SPEED DRIVE:

A complete line of adjustable speed drives for coordinating all kinds of production processes.

Write for Bulletin No. 11-1P1



POLYPHASE:

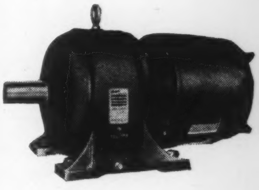
Squirrel Cage Induction—⅛ to 400 H. P.

Wound Rotor Motors—1 to 400 H. P.

Synchronous Motors—20 to 150 H. P.

Write for Bulletin Nos.:

Squirrel Cage, Drip Proof—6-1P1
Squirrel Cage, Splash Proof—6-1P3
Squirrel Cage, Enclosed Fan Cooled—6-1P41
Squirrel Cage, Explosion Proof—6-1P45
Wound Rotor—6-3P1

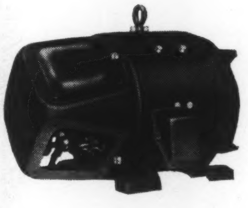


GEAR MOTORS:

⅛ to 15 H. P., single, double and triple gear reduction.

Write for Bulletin Nos.:

⅛ to ¾ H. P.	4-5P21-61
1 to 15 H. P.	4-1P31



DIRECT CURRENT:

All capacities—⅛ to 300 H. P.
Write for Bulletin No. 10-1P1

GENERATORS:

AC, .63 to 250 KVA
DC, .75 to 200 KW

Write for Bulletin Nos.:

AC, .63 to 250 KVA—18-1P21
DC, .75 to 200 KW—18-1P1

823RR

Motors listed above are available in Open Rated Drip Proof, Splash Proof, Totally Enclosed Fan Cooled and Explosion Proof frames—and with a dozen different methods of mounting. They are unusually quiet starting and running and unusually free from vibration.

CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Missouri
Offices and Stock Points in Principal Cities

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To CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Mo.

Please send me the following bulletins:
(Fill in numbers here) ....
....
....
Name.. Title..........................
Company..
Address..
City.. Zone.......... State..........

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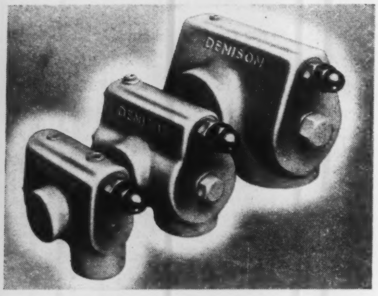
NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 211

Hydraulic Valves

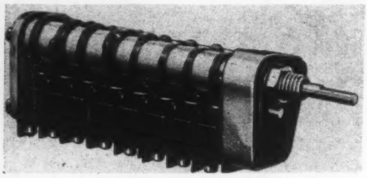
Line of relief valves control pressure in 2000-psi hydraulic circuits. Light and compact in construction, valves have threaded bodies for in-line or T-connections and are available in pipe sizes of ½, ¾, 1¼ and 1½ in. Pressure regulation from 100 to 2000 psi is available in the three smaller sizes, and pressure settings from 150 to 2000 psi are possible in the 1½-in. size. Pilot-operated, the valves are very sensitive to pressure change. Variations in line volume have little effect on opening or closing pressures. Pressure settings are regulated by a single screw adjustment. Made by **Denison Engineering Co.,** 1160 Dublin Rd., Columbus 16, O.



For more data circle MD-65, Page 211

Rotary Selector Switches

Virtually any switching sequence is provided by a series of subminiature rotary selector switch assemblies with two to eight switching units. Each unit is available with two to eight detent positions. Panel-sealed, units are less than 4 in. long and require 1 17/64-in. diameter mounting surface. Extremely small single-pole, double-throw switching units are employed. Switches are available with drilled, solder type or wrap-around turret terminals and are rated for inductive load of 3 amp at 30 v dc and 10 amp at 125 or 250 v ac. Made by Micro Switch Div., **Minneapolis-Honeywell Regulator Co.,** Freeport, Ill.



For more data circle MD-66, Page 211

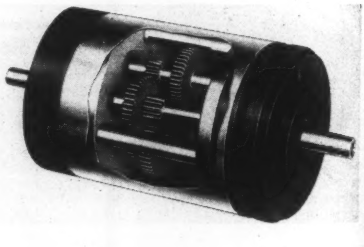
Small Stampings

Over 1000 parts, including solder lugs, terminals, contacts, and corona rings are available as standard items in line of small stampings for radio, electronic and similar uses. Manufactured by high production techniques, parts are supplied to specification within close tolerances. Base metals include brass, copper, beryllium copper, phosphor bronze and steel. Made by **Malco Tool & Mfg. Co.,** Dept. MDC, 4025 W. Lake St., Chicago 24, Ill.

For more data circle MD-67, Page 211

Miniature Speed Reducers

Series of precision miniature speed reducers is available with ratios ranging from 12.5:1 to 10,000:1. ABEC Class 5 ball bearings are used throughout, and gears are cut to AGMA Precision 2 tolerances from stainless steel, or from aluminum bronze for applications requiring very quiet operation. Backlash is less than ½-deg. Basic units 1062 and 1687 measure 1.062 and 1.687 in. in diameter, respectively, and 1.656 and 1.859 in. in length, exclusive of shaft length, which can be specified. Series 1062 is designed

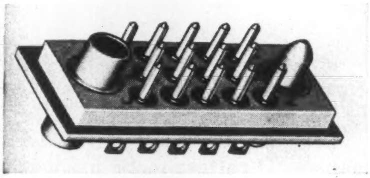


for output torque loads up to 25 oz-in.; 1687 is rated at 100 oz-in. maximum. Applications include electronic controls, actuators, servos, and similar equipment requiring small size and weight. Made by **Bowmar Instrument Corp.,** 2415 Pennsylvania St., Fort Wayne, Ind.

For more data circle MD-68, Page 211

Hermetically Sealed Connector

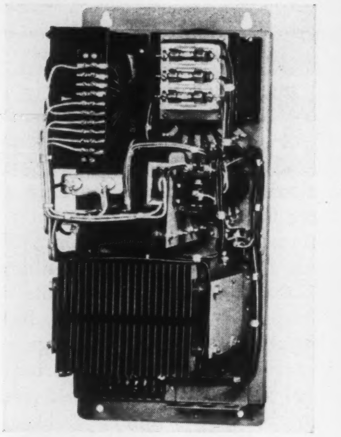
Series HVT rectangular connector has all-glass seal fused to each individual contact and to the body. Shaped to serve as a plug, connector is soldered into the top of the container which holds the component and its wiring. Glass seal prevents leakage in gas and fluid-filled units and shuts out dust, air and moisture. Connector body is precision machined steel; contacts are gold-plated over silver. Standard units mate with standard receptacles and are available with 7, 14, 20 and 34 contacts. Other contact arrangements can be specified. Made by **Viking Electric,** 1061 Ingraham St., Los Angeles 17, Calif.



For more data circle MD-69, Page 211

Adjustable-Speed Drive

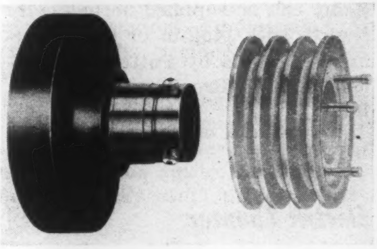
Available in nine sizes from 1/4 to 5 hp, the Franklin Drive uses magnetic amplifiers and selenium rectifiers to control speed of a dc motor. Drive has 100 to 1 speed range with flat speed regulation out to full load at the lowest speed. For a given setting, speed is approximately proportional to supply voltage. Motor speed is proportional to rotation of control shaft. Drives use standard shunt or compound dc motors having base speed of 1750 rpm and voltage rating equal to ac input voltage. Claim is made that rectifiers and amplifiers will not burn or wear out in ten years of normal service. Made by **Franklin Control Corp.,** 1975 S. Allis St., Milwaukee 7, Wis.



For more data circle MD-70, Page 211

Automatic Clutch

Installed without altering present shaft extensions, the 600 series automatic clutch provides load-free starting and idling for gasoline engines from 3 to 10 hp and electric motors from 2 to 5 hp, 1750 rpm. Clutch picks up the load smoothly when the power source is accelerated. Wide selection of detachable sheaves or sprockets is available for use on the unit. Made by **Salsbury Corp.,** 1161 E. Florence Ave., Los Angeles 1, Calif.



For more data circle MD-71, Page 211

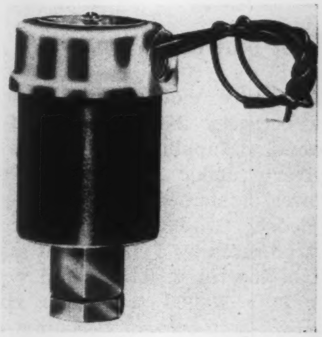
Compressible Liquids

Applicable for cushioning and in hydraulic systems, Comproils are compressible liquids which have lubricating properties. They are compressible only at high pressures. Using distilled water as a standard, type 118 has a compressibility of approximately 11.5 per cent at 20,000 psi. Made by Hydra Spring Div., **Wales-Strippit Corp.,** 345 Payne Ave., North Tonawanda, N. Y.

For more data circle MD-72, Page 211

Solenoid Valves

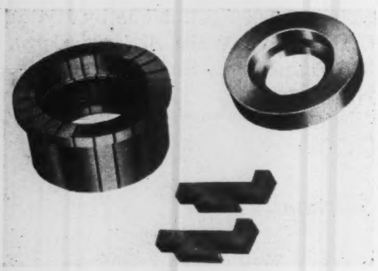
Made with valve bodies of type 303 stainless steel and solenoid armature of type 416 stainless for corrosion resistance, this solenoid direct lift valve is offered in 1/8 and 1/4-in. pipe sizes. Pressure ratings are 5000 psi to 150 F and 2500 psi to 400 F. Orifice sizes range from 1/16 to 3/16-in., depending on pressure requirements and coil used. Paper-wound or glass-impregnated coils are used according to temperature range. Made by **Atkomatic Valve Co.,** Dept. B262, 545 W. Abbott St., Indianapolis 7, Ind.



For more data circle MD-73, Page 211

Sintered Motor Parts

Gramix sintered metal commutator segments, slip rings, pole shoes and bearings for electric motors are compacted under pressure up to 70,000 lb and sintered in controlled atmosphere furnaces. Low production cost is claimed because parts need little or no machining and have a porous structure that requires less metal. Performance and service life are good. A relatively high density provides intimate contact for good conductivity. Parts can be impregnated with a variety of lubricants during man-

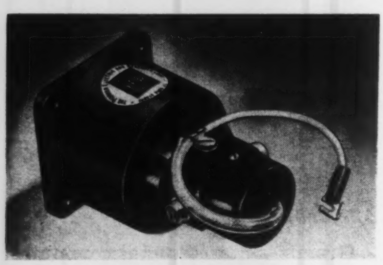


ufacture to give long wear with little or no maintenance. Made by United States Graphite Co., Div. of **Wickes Corp.,** 1621 Holland Ave., Saginaw, Mich.

For more data circle MD-74, Page 211

Motor-Blower Assembly

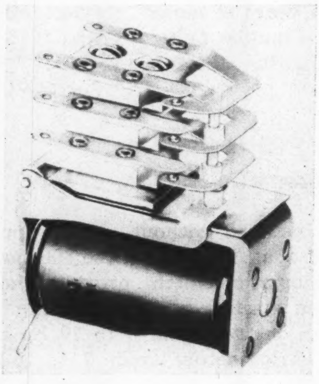
Miniature motor-blower assembly occupies 2¼ x 2¼ x 4-in. space and supplies 24 cfm free air delivery under continuous duty. Blower or suction operation is afforded by two-blade propeller-type fan, powered by a permanent magnet motor rated at 6 to 115 v dc. Speed is 10,000 to 13,000 rpm, with 0.5-amp current consumption. Housing is cast aluminum, and unit can be equipped with a radio noise filter. Blower is available to meet varying industrial and military requirements. Made by **Pioneer Electric and Research Corp.,** 743 Circle Ave., Forest Park, Ill.



For more data circle MD-75, Page 211

Low Loss Relay

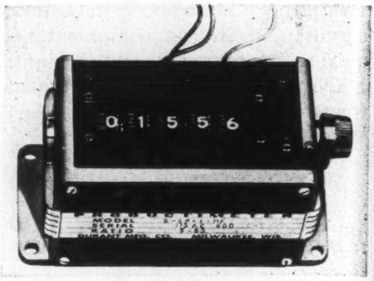
MC relay has high dielectric ceramic insulation and inter-contact capacitance in the order of 1.5 micromicrofarad. It is applicable to radio frequency circuitry where inter-contact capacitance losses are critical. Available with a maximum of three movable and three fixed arms, the relay has palladium contacts rated 1 amp, 28 v dc or 115 v, 60 cycle ac, noninductive load. Gold alloy contacts can be supplied for low-voltage, light-current loads. Coil windings can be provided for operation from 50 to 60 cycle ac or dc with maximum of 22,000 ohms resistance. Power requirement is 150 milliwatts minimum per movable pole. Coils of open relays are varnish-impregnated for protection against moisture and mechanical damage. Relay can be supplied hermetically sealed, with plug-in or solder terminals. Made by **Potter & Brumfield,** 1200 E. Broadway, Princeton, Ind.



For more data circle MD-76, Page 211

Electric Counter

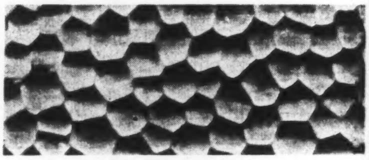
Electrically operated model 5-SP-1-MF predetermined counter can be set at any required number from 0 to 99,999 in the five-figure model or from 0 to 9,999 in the four-figure model to stop production after desired count of completed operations. Counter is enclosed for protection against dirt and moisture and has hinged cover for access to the setting wheels. Maximum operating speed is 600 counts per minute. Switch is rated at 5 amp, 125 or 250-v ac. Contacts are normally-open; normally-closed contacts can be supplied. Standard and special voltages are available. Made by **Durant Mfg. Co.,** 1933 N. Buffum St., Milwaukee 1, Wis.



For more data circle MD-77, Page 211

Patterned Metal

Designated 1-HM, Rigid-tex hammered pattern metal has maximum pattern depth of 0.025-in. on metals up to 0.0312-in. thick. Nondirectional, nongeometric pattern, which is easily matched in fabrication and installation, is available in strip or sheet up to 38 in. wide in a variety of metals including stainless steel, copper, brass and aluminum. Finishes available are mill finish as rolled, mill finish with highlights, colorized and highlighted, painted or porcelain enameled without highlights. Made by **Rigidized Metals Corp.,** 693 Ohio St., Buffalo 3, N. Y.

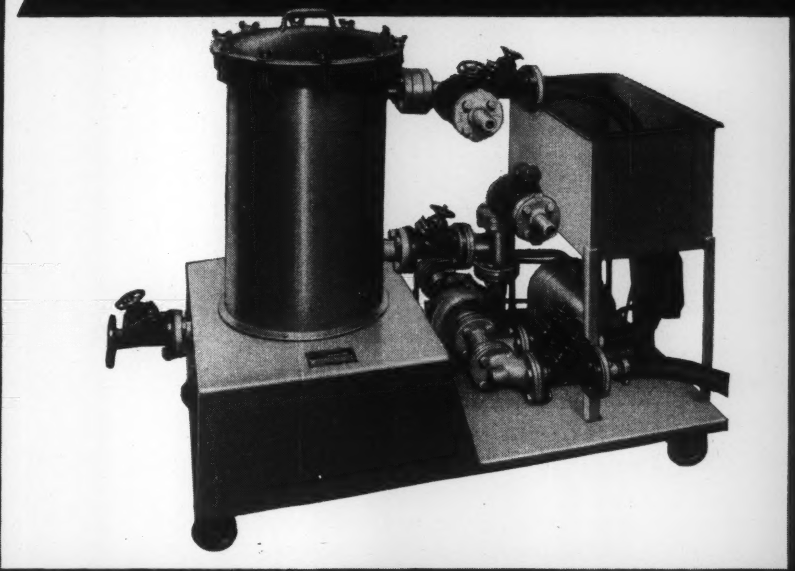


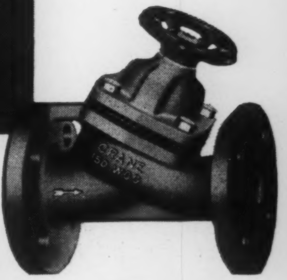
For more data circle MD-78, Page 211

Subminiature Switch

Precision, low-loss, 12-position wafer type selector switch is ¾-in. square. It is designed for constant stability and for use where resistance, inductance and capacitance must be kept to a minimum. Voltage breakdown is 1300 v ac at

HOW TO FILTER ACID PLATING SOLUTIONS





another successful product design with piping equipment by CRANE

Belke Manufacturing Co., of Chicago, Ill., has an answer to the problem of filtering acid plating solutions.

In the compact Belke unit, chemically inert Lucite plates inside a filter bag provide large surface for fast, effective filtering. All tanks and piping are rubber lined to nullify the corrosive action of the plating solutions. Finding valves for such severe service was not as difficult as you might imagine—they're Crane rubber-lined diaphragm valves, regularly available.

In your day-to-day designing, you, too, will find the piping equipment you want in the broad Crane line. You'll also find that specifying goes quicker, since the Crane Catalog provides complete data . . . sizes and dimensions, temperature and pressure ratings, plus details on materials and construction. But even more important, when you specify Crane, you specify *quality* that protects the value of your product.

Crane Y-Pattern Diaphragm Valves . . . preferred by so many designers for their safety and versatility. Crane design assures long diaphragm life, positive shut-off in case of diaphragm failure, accurate seating, better flow control. They're easy to operate . . . simple to maintain. Specify your choice of body materials, trim materials, full linings in screwed or sliding stem patterns. Unlined valves available with screwed or flanged ends. Lined valves, flanged ends only. Sizes up to 6 inch.

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53
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for the
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THE BETTER QUALITY . . . BIGGER VALUE LINE . . . IN BRASS, STEEL, IRON

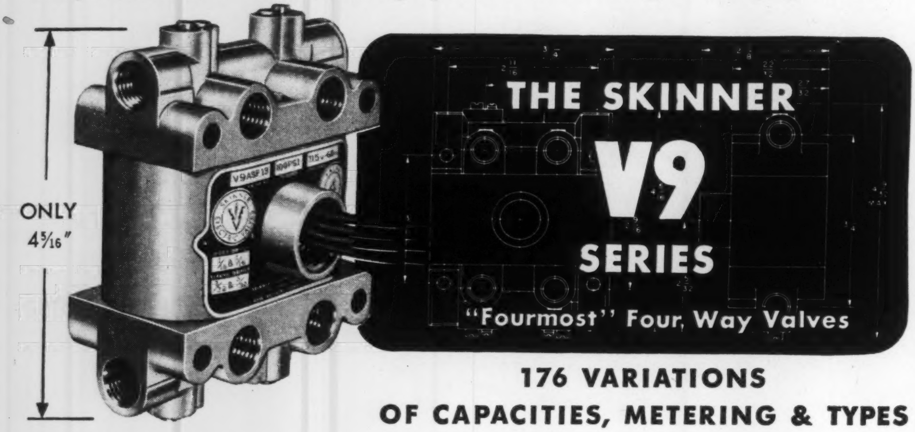
CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

SKINNER INTRODUCES
A NEW SMALLER FOUR-WAY SOLENOID VALVE

for operation of a double-acting cylinder or two single-acting cylinders



176 VARIATIONS OF CAPACITIES, METERING & TYPES

The V9 is offered in 3 basic types: normally closed, normally open, or combination — normally open and normally closed.

Pressures range from 50 to 150 p.s.i. With orifices from $\frac{3}{64}$″ to ⅛″ dia., V9 models have an exceptionally wide range of port locations and metering flow adjustments for Speed Control.

This series meets Skinner's highest traditions of quality. V9 construction is packless, frictionless; there are no troublesome sliding seals or close fits. Bodies are die-cast zinc; internal parts are made of stainless steel. Steel coil housing has zinc chromate finish. Coils are moisture-resistant, varnish-impregnated; molded "waterproof" coils available on request.

LEAKPROOF
Bubble-tight shut-off at all ports

FAST OPERATING
Up to 6 hundred cycles per minute

DIRECT ACTING
Positive spring-loaded operation — *NO* sliding seals, will operate in any position

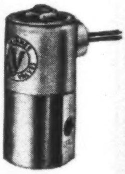
DEPENDABLE
Millions of cycles on most applications — without maintenance

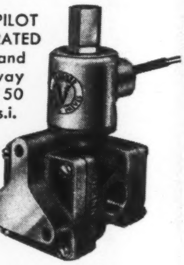
GENERAL SPECIFICATIONS

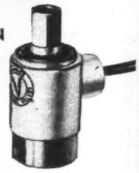
MEDIA	Air, hydraulic oils, and other common media
PIPE SIZE	All pipe connections ¼″ NPT
ELECTRICAL OUTLET	½″ NPT Conduit
DUTY CYCLE	Continuous
VOLTAGE	All common AC and DC voltages
POWER CONSUMPTION	Per Coil — 10 watts Both Coils — 20 watts max.
TEMPERATURE	Minus 65°F. to Plus 150°F.

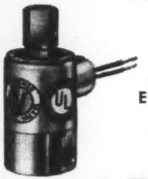
Modern production equipment and methods assure immediate delivery on stock valves, and highest quality standards. Valves are guaranteed for 1 year against defects in materials or workmanship.

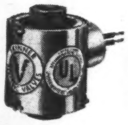
V5-2
SHUT-OFF
2-way
0-1000
p.s.i.

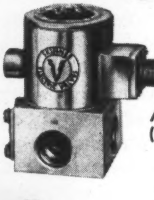

V10
HYDRAULIC
3-way
0-1000
p.s.i.


M3 PILOT
OPERATED
2- and
3-way
5-150
p.s.i.


X5
EXPLOSION
PROOF
(V5 type)
2- and
3-way
0-1000
p.s.i.


V5-3
QUICK
EXHAUST
3-way
0-150
p.s.i.


V2
SHUT-OFF
2-way
0-200
p.s.i.

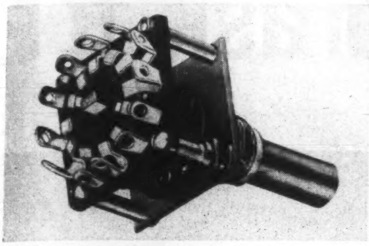

V50
AIRCRAFT
(Aluminum
Body)
2-way
0-3000
p.s.i.

For detailed specifications write for Bulletin No. 532

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIV., The Skinner Chuck Company, 115 Edgewood Ave., New Britain, Connecticut



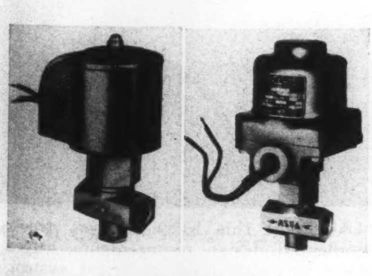
115 v, 60 cycles; current carrying capacity is 3 amp. Switch has 30-degree positive detent mechanism with adjustable stops. Rotor blades and stator contacts are silver alloy; other metal parts are stainless steel. Rotor shaft is available in either ⅛ or ¼-in. diameter. Hole and cutouts are provided in the contact for mechanical attachment of wires. Made by **R. F. Electronics Inc.**, 291 Northeast 61st St., Miami, Fla.

For more data circle MD-79, Page 211

Two-Way Solenoid Valves

Corrosive gases and liquids as well as steam can be handled at temperatures up to 450 F by special 8268 and 8269 two-way solenoid valves shown left and right, respectively. Latter unit has explosionproof solenoid for use in Class I Group D hazardous locations. Bodies are either steel or stainless steel, and in both, all trim is stainless. Valves are designed for normally-closed operations, while normally-open units are available on special order. Impact closing and opening, plus pull of solenoid itself overcomes any tendency for valve to stick. Laminated or solid cores are available. Pipe sizes are ⅜ and ½-in. for both models, and orifice diameters range from ⅛ to ⅜-in. on each size. Manual operators can be supplied on all sizes except those with ⅛-in. orifice. Made by **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.

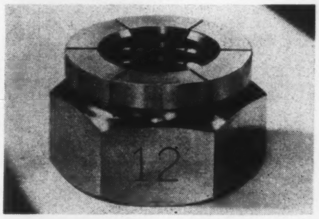
For more data circle MD-80, Page 211



Self-Locking Nuts

Temperatures up to 1200 F do not affect performance of Flexloc series 99F12 self-locking nuts. They are machined from AMS-5642 stainless steel and retain full locking strength at elevated temperatures. Silver plating eliminates galling and thread seizure. Nuts conform to military specification MIL-N-7873 and are made in seven sizes with No. 10 through 9/16-in. diameters and National Fine threads. Made by **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

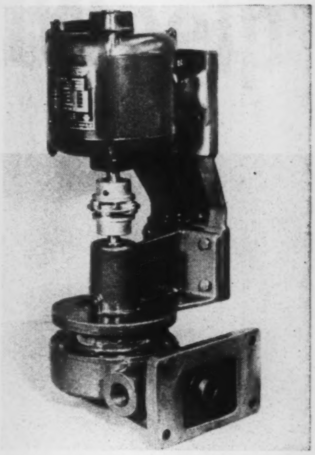
For more data circle MD-81, Page 211



Centrifugal Pumps

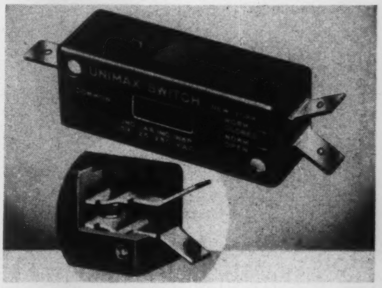
Two redesigned basic models of seal type centrifugal pumps are available with an optional third output through the intake port, which eliminates external piping. Conventional right or left discharge outlets are also available. Pumps are adaptable to both continuous and intermittent operations. Both are designed for flange mounting on the outer surface of a tank or reservoir. Model FB-VBA has an attached motor base bracket to facilitate mounting of any standard motor. Pump and motor are connected by a flexible coupling. Model F-VBA pump, without motor base bracket, uses belt, chain or gear drive, or the pump and motor may be individually mounted and connected by a flexible coupling. Sizes range from 1/20 to 5 hp. Larger sizes are rated up to 174 gpm at free flow and 36 gpm at 115 ft of head (50 psi), based on water at 60 F. Made by Pioneer Pump Div., **Detroit Harvester Co.**, 14300 Tireman Ave., Detroit 28, Mich.

For more data circle MD-82, Page 211

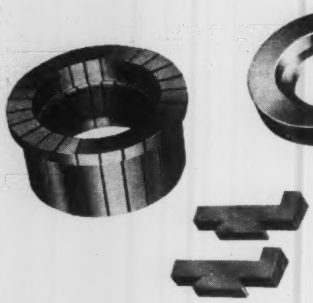


Snap-Action Switch

Type WL precision switch is rated at 15 amp, 125 or 250 v ac. Quick-connect terminals are integral with the current-carrying parts of the switch, which minimizes heating and increases switch life. Switch is contained in a molded phenolic housing 1¾ in. long, ⅝-in. wide and 11/16-in. deep. Model WLL is available with leaf-spring actuator. Applications include household and office appliances as well as industrial



(*Continued on Page* 224)



ufacture to give long wear with little or no maintenance. Made by United States Graphite Co., Div. of **Wickes Corp.**, 1621 Holland Ave., Saginaw, Mich.

For more data circle MD-74, Page 211

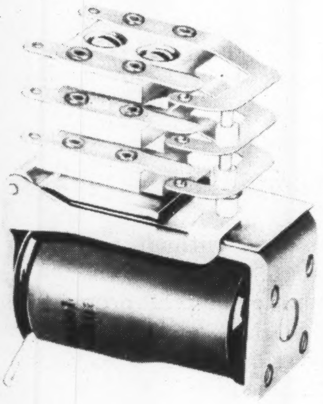
Motor-Blower Assembly

Miniature motor-blower assembly occupies 2¼ x 2¼ x 4-in. space and supplies 24 cfm free air delivery under continuous duty. Blower or suction operation is afforded by two-blade propeller-type fan, powered by a permanent magnet motor rated at 6 to 115 v dc. Speed is 10,000 to 13,000 rpm, with 0.5-amp current consumption. Housing is cast aluminum, and unit can be equipped with a radio noise filter. Blower is available to meet varying industrial and military requirements. Made by **Pioneer Electric and Research Corp.**, 743 Circle Ave., Forest Park, Ill.

For more data circle MD-75, Page 211

Low Loss Relay

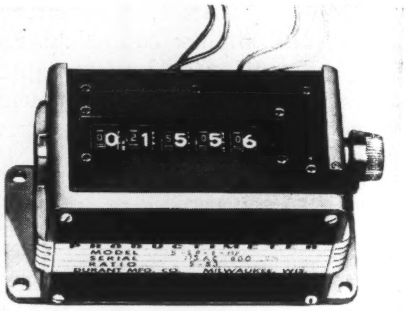
MC relay has high dielectric ceramic insulation and inter-contact capacitance in the order of 1.5 micromicrofarad. It is applicable to radio frequency circuitry where inter-contact capacitance losses are critical. Available with a maximum of three movable and three fixed arms, the relay has palladium contacts rated 1 amp, 28 v dc or 115 v, 60 cycle ac, noninductive load. Gold alloy contacts can be supplied for low-voltage, light-current loads. Coil windings can be provided for operation from 50 to 60 cycle ac or dc with maximum of 22,000 ohms resistance. Power requirement is 150 milliwatts minimum per movable pole. Coils of open relays are varnish-impregnated for protection against moisture and mechanical damage. Relay can be supplied hermetically sealed, with plug-in or solder terminals. Made by **Potter & Brumfield,** 1200 E. Broadway, Princeton, Ind.



For more data circle MD-76, Page 211

Electric Counter

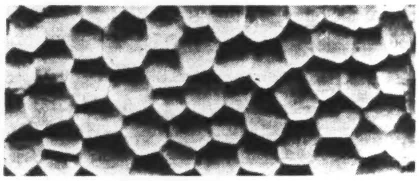
Electrically operated model 5-SP-1-MF predetermined counter can be set at any required number from 0 to 99,999 in the five-figure model or from 0 to 9,999 in the four-figure model to stop production after desired count of completed operations. Counter is enclosed for protection against dirt and moisture and has hinged cover for access to the setting wheels. Maximum operating speed is 600 counts per minute. Switch is rated at 5 amp, 125 or 250-v ac. Contacts are normally-open; normally-closed contacts can be supplied. Standard and special voltages are available. Made by **Durant Mfg. Co.**, 1933 N. Buffum St., Milwaukee 1, Wis.



For more data circle MD-77, Page 211

Patterned Metal

Designated 1-HM, Rigid-tex hammered pattern metal has maximum pattern depth of 0.025-in. on metals up to 0.0312-in. thick. Nondirectional, nongeometric pattern, which is easily matched in fabrication and installation, is available in strip or sheet up to 38 in. wide in a variety of metals including stainless steel, copper, brass and aluminum. Finishes available are mill finish as rolled, mill finish with highlights, colorized and highlighted, painted or porcelain enameled without highlights. Made by **Rigidized Metals Corp.**, 693 Ohio St., Buffalo 3, N. Y.

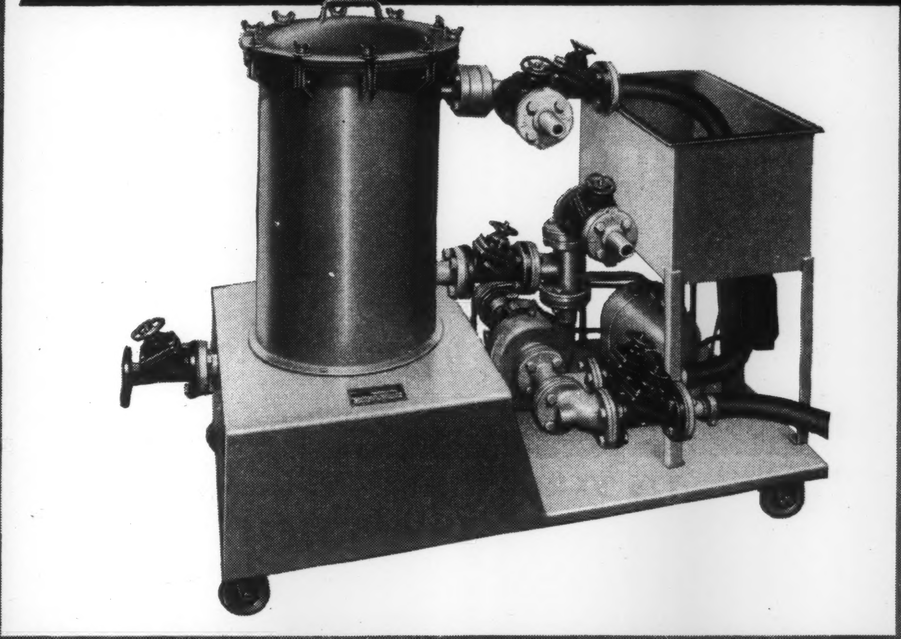


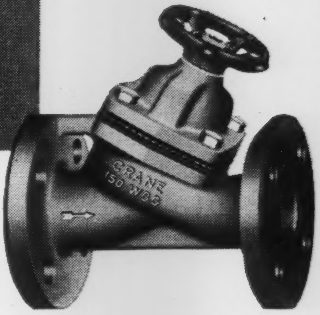
For more data circle MD-78, Page 211

Subminiature Switch

Precision, low-loss, 12-position wafer type selector switch is ¾ in. square. It is designed for constant stability and for use where resistance, inductance and capacitance must be kept to a minimum. Voltage breakdown is 1300 v ac at

HOW TO FILTER ACID PLATING SOLUTIONS





another successful product design with piping equipment by CRANE

Belke Manufacturing Co., of Chicago, Ill., has an answer to the problem of filtering acid plating solutions.

In the compact Belke unit, chemically inert Lucite plates inside a filter bag provide large surface for fast, effective filtering. All tanks and piping are rubber lined to nullify the corrosive action of the plating solutions. Finding valves for such severe service was not as difficult as you might imagine—they're Crane rubber-lined diaphragm valves, regularly available.

In your day-to-day designing, you, too, will find the piping equipment you want in the broad Crane line. You'll also find that specifying goes quicker, since the Crane Catalog provides complete data . . . sizes and dimensions, temperature and pressure ratings, plus details on materials and construction. But even more important, when you specify Crane, you specify *quality* that protects the value of your product.

Crane Y-Pattern Diaphragm Valves . . . preferred by so many designers for their safety and versatility. Crane design assures long diaphragm life, positive shut-off in case of diaphragm failure, accurate seating, better flow control. They're easy to operate . . . simple to maintain. Specify your choice of body materials, trim materials, full linings in screwed or sliding stem patterns. Unlined valves available with screwed or flanged ends. Lined valves, flanged ends only. Sizes up to 6 inch.

CRANE
VALVES
FITTINGS
PIPE
FABRICATED
PIPING
53
CRANE CO.

**YOU'LL FIND IT HERE
. . . IN YOUR
CRANE CATALOG**

for the
THRIFTY
BUYER
and Specifier

THE BETTER QUALITY . . . BIGGER VALUE LINE . . . IN BRASS, STEEL, IRON

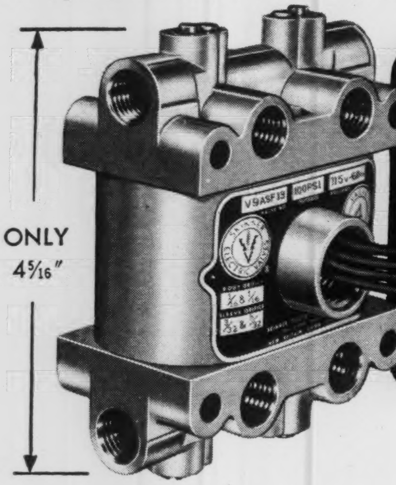
CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

SKINNER INTRODUCES
A NEW SMALLER FOUR-WAY
SOLENOID VALVE

for operation of a double-acting cylinder or two single-acting cylinders



THE SKINNER
V9
SERIES
"Fourmost" Four Way Valves

176 VARIATIONS OF CAPACITIES, METERING & TYPES

The V9 is offered in 3 basic types: normally closed, normally open, or combination — normally open and normally closed.

Pressures range from 50 to 150 p.s.i. With orifices from $\frac{3}{64}$" to $\frac{1}{8}$" dia., V9 models have an exceptionally wide range of port locations and metering flow adjustments for Speed Control.

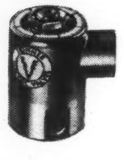
This series meets Skinner's highest traditions of quality. V9 construction is packless, frictionless; there are no troublesome sliding seals or close fits. Bodies are die-cast zinc; internal parts are made of stainless steel. Steel coil housing has zinc chromate finish. Coils are moisture-resistant, varnish-impregnated; molded "waterproof" coils available on request.

LEAKPROOF
Bubble-tight shut-off at all ports

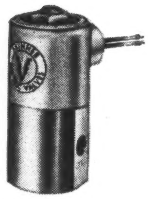
FAST OPERATING
Up to 6 hundred cycles per minute

DIRECT ACTING
Positive spring-loaded operation — *NO* sliding seals, will operate in any position

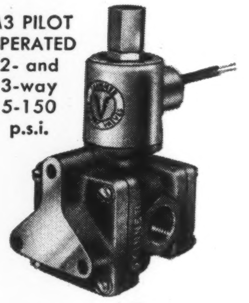
DEPENDABLE
Millions of cycles on most applications — without maintenance



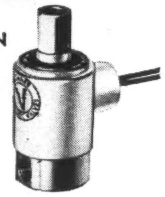
V5-2
SHUT-OFF
2-way
0-1000
p.s.i.



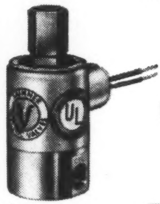
V10
HYDRAULIC
3-way
0-1000
p.s.i.



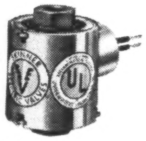
M3 PILOT OPERATED
2- and
3-way
5-150
p.s.i.



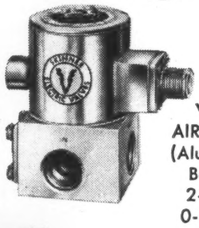
X5
EXPLOSION PROOF
(V5 type)
2- and
3-way
0-1000
p.s.i.



V5-3
QUICK EXHAUST
3-way
0-150
p.s.i.



V2
SHUT-OFF
2-way
0-200
p.s.i.



V50
AIRCRAFT
(Aluminum Body)
2-way
0-3000
p.s.i.

GENERAL SPECIFICATIONS

MEDIA.........Air, hydraulic oils, and other common media
PIPE SIZE....................All pipe connections $\frac{1}{4}$" NPT
ELECTRICAL OUTLET..................$\frac{1}{2}$" NPT Conduit
DUTY CYCLE...............................Continuous
VOLTAGE................All common AC and DC voltages
POWER CONSUMPTION..............Per Coil — 10 watts
Both Coils — 20 watts max.
TEMPERATURE............... Minus 65°F. to Plus 150°F.

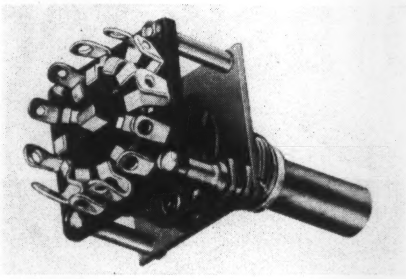
Modern production equipment and methods assure immediate delivery on stock valves, and highest quality standards. Valves are guaranteed for 1 year against defects in materials or workmanship.

For detailed specifications write for Bulletin
No. 532

SKINNER ELECTRIC VALVES®

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVE DIV., The Skinner Chuck Company, 115 Edgewood Ave., New Britain, Connecticut

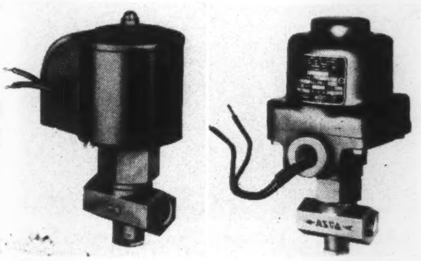


115 v, 60 cycles; current carrying capacity is 3 amp. Switch has 30-degree positive detent mechanism with adjustable stops. Rotor blades and stator contacts are silver alloy; other metal parts are stainless steel. Rotor shaft is available in either 1/8 or 1/4-in. diameter. Hole and cutouts are provided in the contact for mechanical attachment of wires. Made by **R. F. Electronics Inc.**, 291 Northeast 61st St., Miami, Fla.

For more data circle MD-79, Page 211

Two-Way Solenoid Valves

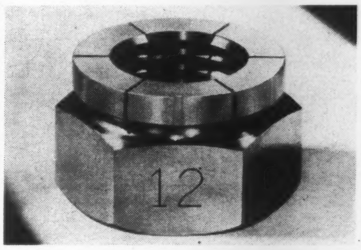
Corrosive gases and liquids as well as steam can be handled at temperatures up to 450 F by special 8268 and 8269 two-way solenoid valves shown left and right, respectively. Latter unit has explosionproof solenoid for use in Class I Group D hazardous locations. Bodies are either steel or stainless steel, and in both, all trim is stainless. Valves are designed for normally-closed operations, while normally-open units are available on special order. Impact closing and opening, plus pull of solenoid itself overcomes any tendency for valve to stick. Laminated or solid cores are available. Pipe sizes are 3/8 and 1/2-in. for both models, and orifice diameters range from 1/8 to 3/8-in. on each size. Manual operators can be supplied on all sizes except those with 1/8-in. orifice. Made by **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.



For more data circle MD-80, Page 211

Self-Locking Nuts

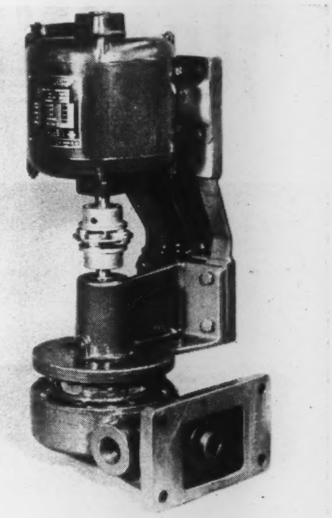
Temperatures up to 1200 F do not affect performance of Flexloc series 99F12 self-locking nuts. They are machined from AMS-5642 stainless steel and retain full locking strength at elevated temperatures. Silver plating eliminates galling and thread seizure. Nuts conform to military specification MIL-N-7873 and are made in seven sizes with No. 10 through 9/16-in. diameters and National Fine threads. Made by **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.



For more data circle MD-81, Page 211

Centrifugal Pumps

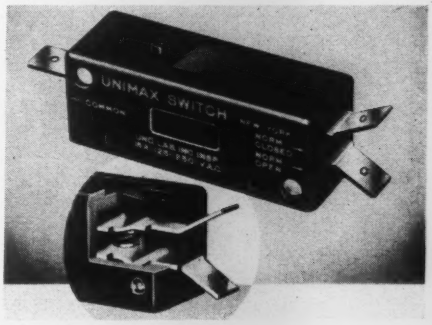
Two redesigned basic models of seal type centrifugal pumps are available with an optional third output through the intake port, which eliminates external piping. Conventional right or left discharge outlets are also available. Pumps are adaptable to both continuous and intermittent operations. Both are designed for flange mounting on the outer surface of a tank or reservoir. Model FB-VBA has an attached motor base bracket to facilitate mounting of any standard motor. Pump and motor are connected by a flexible coupling. Model F-VBA pump, without motor base bracket, uses belt, chain or gear drive, or the pump and motor may be individually mounted and connected by a flexible coupling. Sizes range from 1/20 to 5 hp. Larger sizes are rated up to 174 gpm at free flow and 36 gpm at 115 ft of head (50 psi), based on water at 60 F. Made by Pioneer Pump Div., **Detroit Harvester Co.**, 14300 Tireman Ave., Detroit 28, Mich.



For more data circle MD-82, Page 211

Snap-Action Switch

Type WL precision switch is rated at 15 amp, 125 or 250 v ac. Quick-connect terminals are integral with the current-carrying parts of the switch, which minimizes heating and increases switch life. Switch is contained in a molded phenolic housing 1¾ in. long, 5/8-in. wide and 11/16-in. deep. Model WLL is available with leaf-spring actuator. Applications include household and office appliances as well as industrial



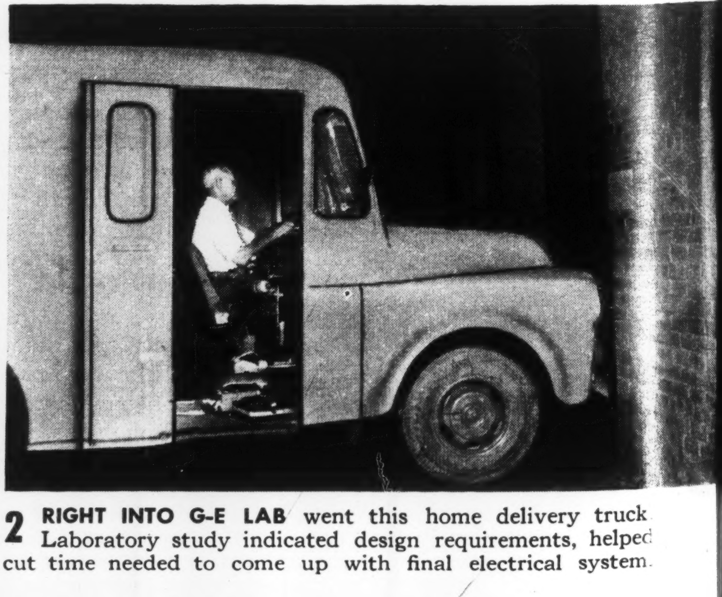
(*Continued on Page* 224)

This Allen Cooler truck went right into our lab and proved . . .

Why it pays to ask for

G-E ENGINEERING solved a complex truck refrigeration problem for Allen Cooler. The General Electric system provides uniform temperature when operating off the engine drive or on 115-volt AC plug-in during off hours. System was created by modifying standard G-E components, including an alternator, a rectifier, and two fractional-hp motors, and adding a regulator.

1 **PROBLEM PRESENTED** to G.E. by Allen Cooler design engineers called for flexible 24-hour truck refrigeration, maximum storage capacity, and minimum cost.



2 **RIGHT INTO G-E LAB** went this home delivery truck Laboratory study indicated design requirements, helped cut time needed to come up with final electrical system.

G-E motor application help

G-E engineers design electrical system to provide low-cost truck refrigeration during deliveries . . . plus overnight plug-in service

If you have a difficult motor application problem, you'll find it pays to take advantage of the technical skills and the resourceful engineering of General Electric's Specialty Component Motor Department. Here's how Allen Cooler profited:

Allen Cooler design engineers wanted this: an electrical system for refrigerating milk delivery trucks which would operate at full cooling capacity at engine idling speed. An additional requirement was that the system also operate on 115-volt AC during off hours, thus providing 24-hour service. However operated, the system should maintain temperatures between 35 and 40 degrees at all times.

G-E motor engineers went to work on these specifications. They devised a packaged electrical system incorporating an alternator, a compressor-drive motor, an evaporator motor, a regulator, and a rectifier. Made up of these skillfully integrated components, the compact system provides reliable cooling with maximum truck-storage capacity.

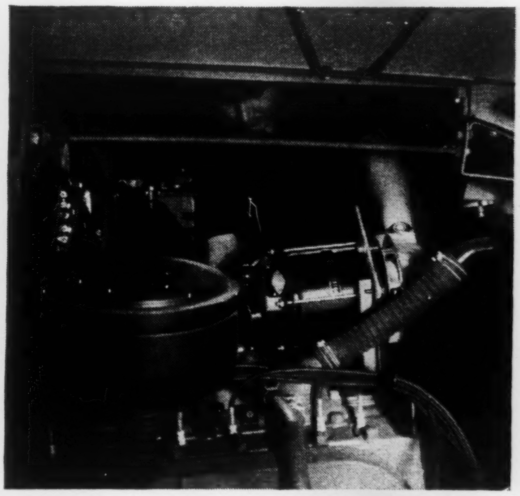
Working closely with the Allen Cooler engineers, General Electric engineers installed the packaged system in a dairy truck and tested it under actual operating conditions. The amazing performance: during 6000 miles of hot weather service, there was not a single operational complaint.

Next time you have a tough motor application problem, bring it to General Electric. You'll be taking advantage of engineering skills unmatched anywhere. To arrange for this service, contact your nearby G-E Apparatus Sales Office. For more information, write General Electric Company, Section 704-27, Schenectady 5, New York.

Progress is our most important product

GENERAL ELECTRIC

3 **ACTUAL CONDITIONS** of operation were simulated. In this cell, temperature control accuracy was checked.



4 **INSTALLATION OF ALTERNATOR** under truck's hood. Unit must withstand heat, be compact, yet provide sufficient capacity.

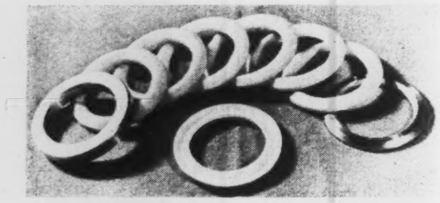
5 **FINAL UNIT** uses minimum space, maintains even temperatures during deliveries, permits plug-in service.

(*Continued from Page* 221)

equipment. Made by Unimax Switch Div., **W. L. Maxson Corp.,** 460 W. 34th St., New York 1, N. Y.

For more data circle MD-83, Page 211

Flexible V-Ring

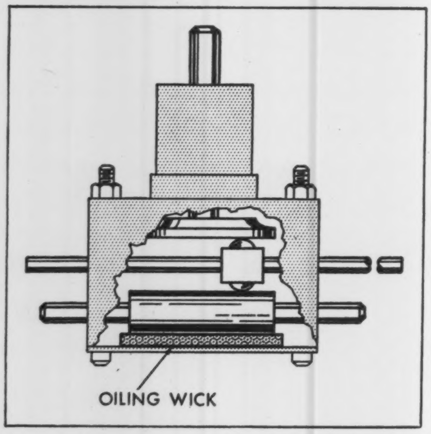


Super-Thin V-rings for pumps, valves and all types of packing are extremely flexible and have cross-sections as thin as 0.015-in. Increased resilience makes possible a tighter seal at lower pressure. Fabricated from Teflon, the V-rings are chemically inert, suitable for use at temperatures from −150 to 550 F and have a natural smoothness that reduces friction. Seals are supplied as a series of cones, to fit various spindle diameters and stuffing box diameters and lengths. Made by **Reid Enterprises,** 3715 Santa Fe Ave., Los Angeles 58, Calif.

For more data circle MD-84, Page 211

Ball and Disk Integrator

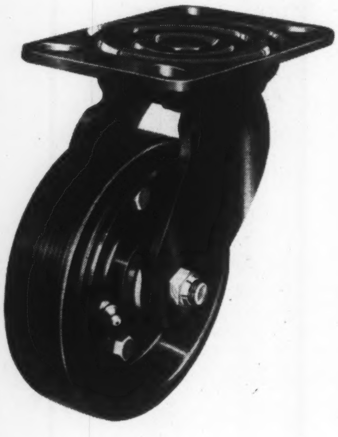
Improved ball and disk integrator is used in totalizing, rate determination, in differential analyzers, or as a closed loop mechanical servo-element or a precision variable-speed drive. Highly finished balls and tungsten carbide disk are employed, and permanent lubricating wick uses lubricating oil to Army, Navy and Air Force specifications. Unit weighs 21 oz, is $1\frac{7}{8}$ in. wide, $2\frac{3}{4}$ in. long and $3\frac{1}{4}$ in. high. Made by **Librascope, Inc.,** 1607 Flower St., Glendale, Calif.



For more data circle MD-85, Page 211

Industrial Casters

Neoprene seals on 5200 series casters keep lubricant in the raceways and seal out dirt, water and chemicals. Five types of wheels, including MB industrial type with sealed roller bearings, are available with load capacities ranging up to 1200 lb per caster. A rigid model is provided to match each swivel rig in the series. Cold forging process employed in manufacturing the casters causes the metal to flow to points of greatest wear and stress. Made by **Rapids-Standard Co. Inc.,** Casters Dept., 342 Rapistan Bldg., Grand Rapids 2, Mich.



For more data circle MD-86, Page 211

Solenoid Valve

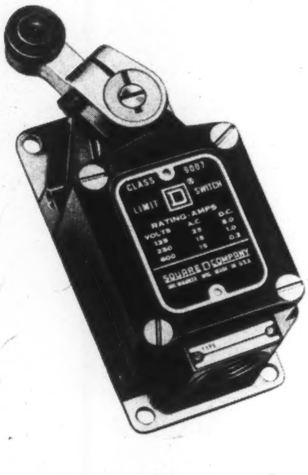
Increases in operating speeds of small air and hydraulic cylinders are made possible by V5-3 Quick Exhaust solenoid valve, which more than doubles the standard speed of the cylinder return stroke. Fabricated from stainless steel and having positive spring-loaded operation, valves can be provided for $\frac{1}{8}$ or $\frac{1}{4}$-in. NPT pipe connections. Units are available in a complete range of alternating and direct current voltages. Pressure ratings and inlet orifices are 50 psi and $\frac{1}{8}$-in., 75 psi and 3/32-in., 100 psi and 1/16-in., and 150 psi and 3/64-in. Made by Skinner Electric Valve Div., **Skinner Chuck Co.,** 95 Edgewood Ave., New Britain, Conn.

SKINNER ELECTRIC VALVES

For more data circle MD-87, Page 211

Limit Switch

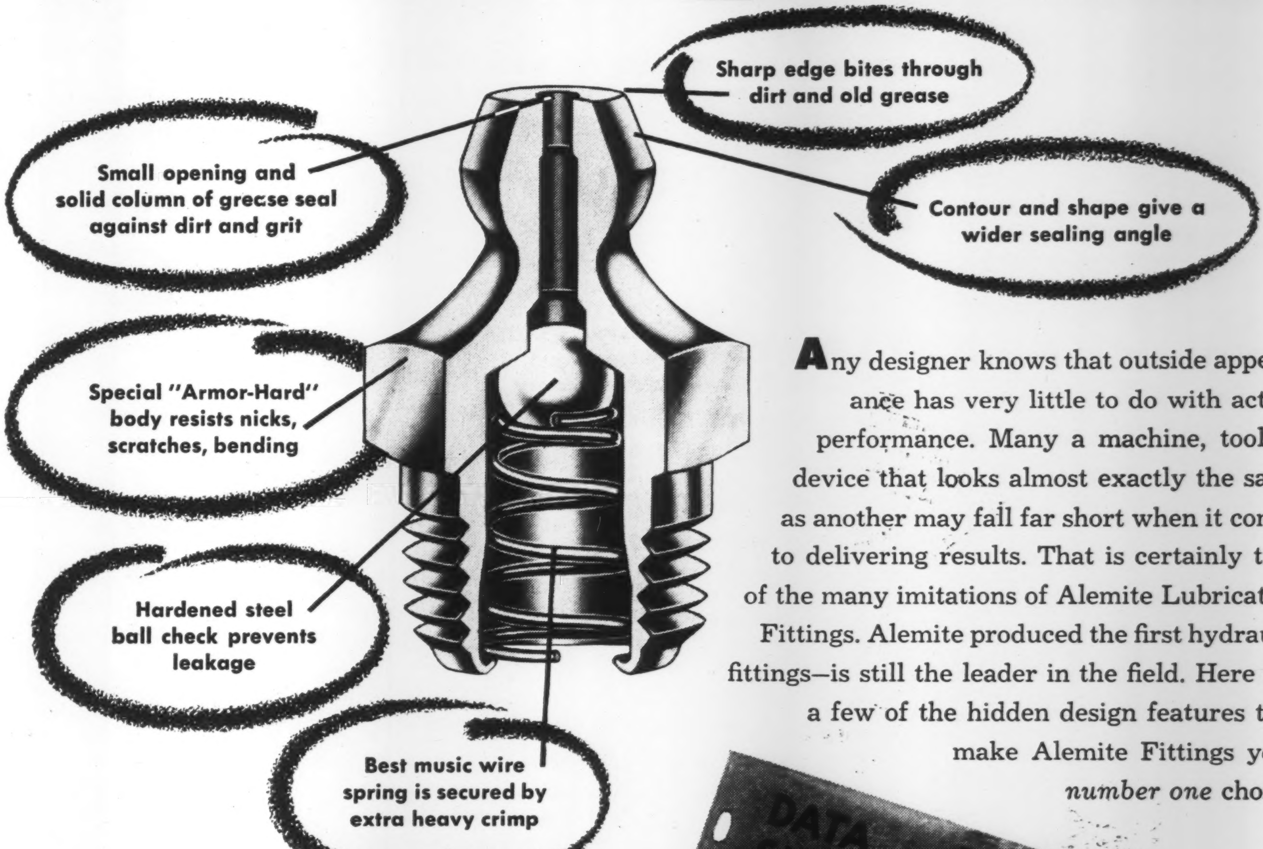
Class 9007 machine tool limit switch is adjusted with a screwdriver to obtain any one of 11 different contact operating sequences. Unit is available with a variety of operating lever arms which can be mounted in any angular position. Although only a small travel is required for operation, ap-



Important design features inside the fitting make the difference!

Genuine Alemite Fittings

your number one choice for any lubrication applicat▮▮!


Sharp edge bites through dirt and old grease
Small opening and solid column of grease seal against dirt and grit
Contour and shape give a wider sealing angle
Special "Armor-Hard" body resists nicks, scratches, bending
Hardened steel ball check prevents leakage
Best music wire spring is secured by extra heavy crimp

Any designer knows that outside appearance has very little to do with actual performance. Many a machine, tool or device that looks almost exactly the same as another may fall far short when it comes to delivering results. That is certainly true of the many imitations of Alemite Lubrication Fittings. Alemite produced the first hydraulic fittings—is still the leader in the field. Here are a few of the hidden design features that make Alemite Fittings your *number one* choice.

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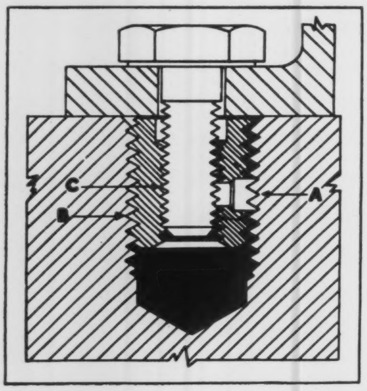
proximately 80 degrees overtravel is provided in both directions. Diecast unit is neoprene gasketed and is water, oil and dust-tight. Seven types of baseplates permit mounting in various positions. Made by **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

For more data circle MD-88, Page 211

Threaded Inserts

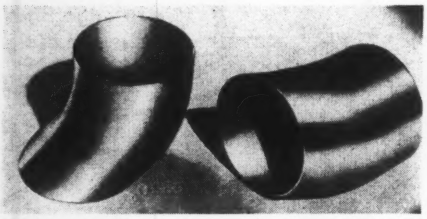
Self-locking Nylok inserts, used principally in nonferrous forgings, castings and extrusions, eliminate counter-boring and special tapping. No special tools are required for insertion or removal. Resilient nylon plug (A) sets up lateral thrust on both internal and external threads, wedging mating threads together both on casting and bolt (B) and (C). No galling, thread distortion, nor mutilation of mating threads results. All locking action is on threads, and locking is positive. Inserts may be reused. Made by **Nylok Corp.**, Elmira Heights, N. Y.



For more data circle MD-89, Page 211

Thin-Wall Tubing

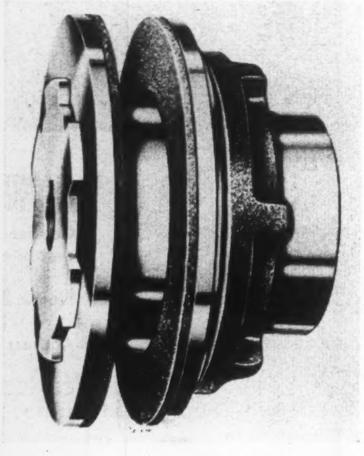
Flexon thin-wall, stainless steel tubing in standard and high strength types meets requirements of corrosion resistance, light weight and special shapes. Standard straight-wall tube is available in 15 outside diameters from 1 to 6 in.; high strength tube is offered in 13 diameters from $1\frac{1}{2}$ to 6 in. All but smaller sizes are available in four wall thicknesses designed to withstand various pressures. Shaped parts are formed from single pieces of tubing. Fittings and parts can be attached to the straight or flexible tubing by resistance circumferential seam welding. Made by **Flexonics Corp.**, 1339 S. Third Ave., Maywood, Ill.



For more data circle MD-90, Page 211

Overload Protection Devices

Available in 11 models with torque capacities ranging from 20 to 620 lb-ft, adjustable Torque Limiters have powdered metal bushings on which such drive components as chain sprockets, V-belt pulleys or gears can be mounted. They act as automatic shear pin mechanisms and are torque sensitive, compact, need no resetting and are tamperproof. Typical applications include drives for conveyors, handling equipment, automated machine tools and packaging machinery. Device consists of driving or driven member (sprocket, sheave or gear) combined with spring loaded friction clutch that can be adjusted to slip when desired torque is exceeded, at which point driven member breaks away from clutch facings and slips at from 1/3 to $\frac{1}{2}$ torque setting. Various models can be mounted on shafts from $\frac{1}{2}$ to $2\frac{1}{2}$ in. diameter. Plate diameters are 3 to 10 in., and hub lengths are 2 to $3\frac{7}{8}$ in. Made by **Morse Chain Co.**, 7601 Central Ave., Detroit 10, Mich.



For more data circle MD-91, Page 211

Continuous-Duty Motor

Available in ratings of $\frac{1}{3}$ and $\frac{1}{2}$-hp, 1750 and 3500 rpm, single and polyphase, Amco motor drive can be used in applications requiring controlled acceleration, constant speed and rapid braking. Heavy flywheel maintains constant speed, even on heavy overloads, when clutch is engaged. When clutch is disengaged, rapid braking is obtained with disk type brake. Braking power can be spring-adjusted to required amoun Motor can be operated manuall by foot treadle or controlled automatically by electric solenoid o air cylinder. Made by **America Safety Table Co. Inc.**, Reading, P

AMCO MOTOR DRIVE
AMERICAN SAFETY TABLE CO.

For more data circle MD-92, Page 211

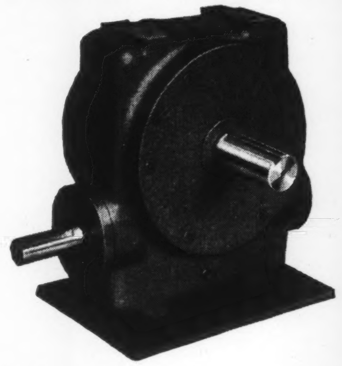
Spring Steel Fastener

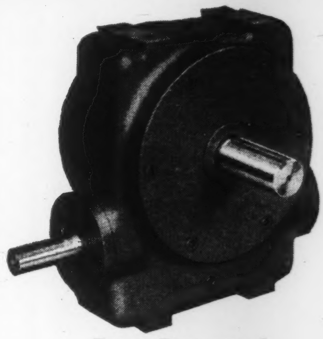
Type F Pushnut arched spring-steel fastener slips over unthreaded studs or rods and locks at pressure of applicator. Spring tension pulls parts firmly and gripping

D.O.James

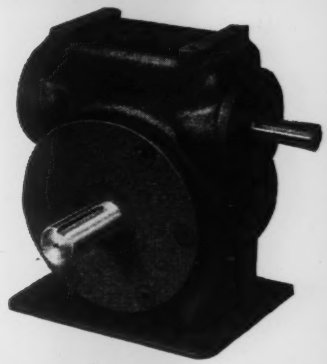
TYPE "S" WORM GEAR SPEED REDUCERS

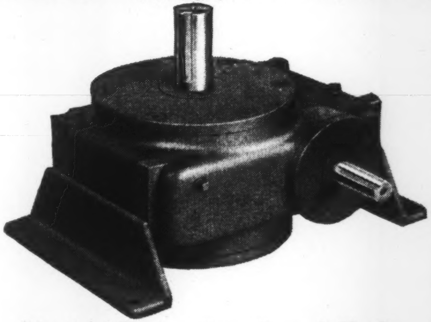
RATIOS FROM 5.66:1 TO 100:1 — .04 HP TO 15.6 HP


Horizontal Type—Worm at Bottom
Sizes 17S, 22S, 26S, 33S

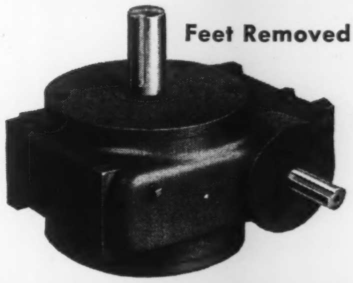

Base Removed

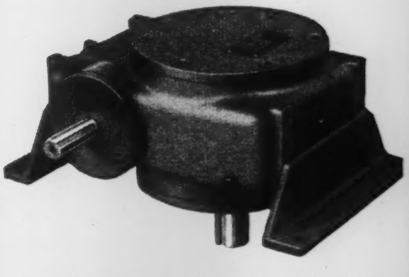
Sizes 17 to 33 inclusive have detachable bases or feet, are adaptable to horizontal or vertical applications, convertible from one to the other, or may be used without bases to suit particular installations.

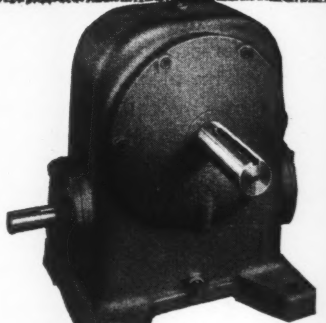

Horizontal Type—Worm at Top
Sizes 17ST, 22ST, 26ST, 33ST

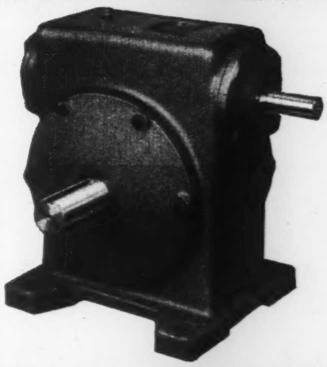

Vertical Type—Slow Speed Shaft Extends Upward
Sizes 17SV, 22SV, 26SV, 33SV

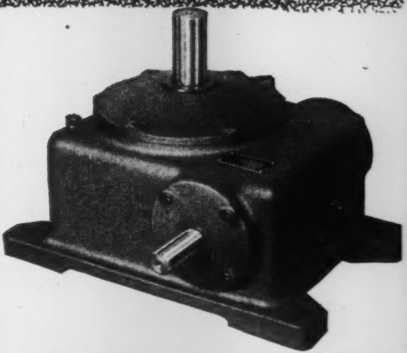
Feet Removed




Vertical Type—Slow Speed Shaft Extends Downward
Sizes 17SV, 22SV, 26SV, 33SV


Horizontal Type—Worm at Bottom
Sizes 38S, 42S, 46S, 54S


Horizontal Type—Worm at Top
Sizes 38ST, 42ST, 46ST, 54ST


Vertical Type—Slow Speed Shaft Extends Downward or Upward
Sizes 38SV, 42SV, 46SV, 54SV

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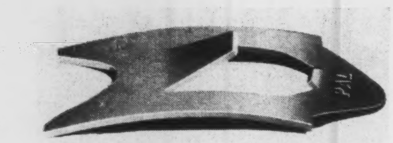
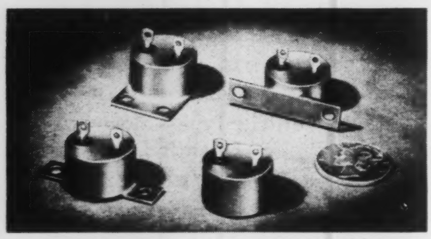


tangs hold tightly to prevent rattling or loosening in service. Fastener is offered for 3/32, ⅛ and 3/16-in. rods or studs in plain steel, Parkerized or cadmium finishes. Made by **Palnut Co.,** 61 Cordier St., Irvington 11, N. J.

For more data circle MD-93, Page 211

Sealed Thermostats

For applications where moisture, corrosion, dust or altitude might adversely affect thermostat life or performance or for use in explosive atmospheres, Stemco type A hermetically sealed thermostats employ a disk type bimetal thermal element for quick make-and-break operation. This insulated, electrically independent element, located close to the controlled surface, eliminates false cycling. Operating temperature range is from −40 to 300 F. A wide variety of mounting arrangements is available. Made by **Stevens Mfg. Co. Inc.,** 69 S. Walnut St., Mansfield, O.



For more data circle MD-94, Page 211

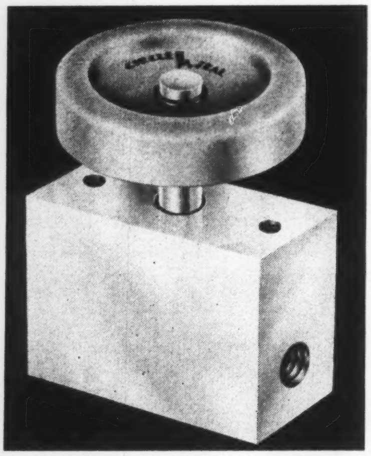
Flexible Coupling

Bonded-rubber coupling transmits a torque of 200 lb-in. with 7-deg angular misalignment. Rated torque is transmitted in uninterrupted service. Motion in torsional, axial, radial and angular directions is accommodated by the bonded-rubber members of the coupling. The elastomer is securely bonded to the steel inner members of the individual joints, providing good stability under axial thrust. The rubber shoulders project outward, locating the joints axially and providing snubbing protection for thrust shock loads. Lubrication and maintenance are not required. Arrangement of the coupling elements in series permits a soft torsional spring rate, providing good isolation of torsional vibration. Coupling length can be changed to provide the required parallel misalignment for best utilization of available space. Made by **Lord Mfg. Co.,** West Twelfth St., Erie, Pa.

For more data circle MD-95, Page 211

Manual Control Valves

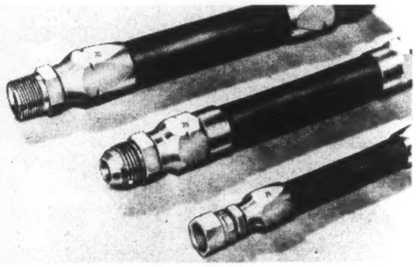
Designed for either hydraulic or pneumatic service, 900 series manually controlled shut-off and throttling valves are rated at from 0 to 3000 psi. Leakproof shut-off is provided by an O-ring which is withdrawn completely from the fluid stream as soon as valve begins to open to prevent damage or wash-out. Throttling is accomplished by a conical metal plug which varies the orifice area. All functions are controlled by a single motion of the hand knob. Valves operate with low pressure drop even when pressure and flow rate are high. Made by **James-Pond-Clark,** 2181 E. Foothill Blvd., Pasadena 8, Calif.



For more data circle MD-96, Page 211

Hose Couplings

Addition to line of reusable type Hoze-lok fittings eliminates need for reducers in many combination size connections when diameter reduction from hose to tubing is desired. Industrial hose couplings conform to SAE hose fittings standards and applicable specifications of JIC hydraulic standards. Fittings are suited for low, medium and high pressure installations and are made for SAE 100R1 and 100R2 rubber-covered single and double wire braid hose and SAE 100R5 cotton-covered, single wire braid hose. Made by **Parker Appliance Co.,** 17325 Euclid Ave., Cleveland 12, O.



For more data circle MD-97, Page 211

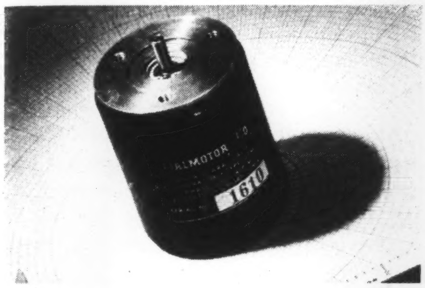
Miniature Generator

Rated for continuous duty with an output frequency of 20 cycles per second and a maximum of 3 per cent harmonic distortion, Dalmotor type 44A permanent-magnet generator is used for instrument indicating and other similar applications. Voltage is linear with

(*Continued on Page* 237)

(*Continued from Page* 228)

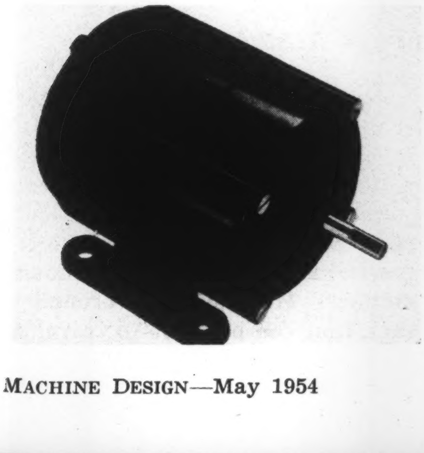
speed, and the unit develops 33 v two-phase ac at 4500 rpm. Internal winding resistance is 30,000 ohms per phase. Pressure sealed, the generator has permanently lubricated bearings. Electrical leads or terminations can be supplied in a number of different types as required, and special shaft arrangements including splines, keyways and gears can be supplied. Size is 1¾ in. OD, 2⅛ in. long, with a 5/32-in. shaft extending 0.34-in. Made by **Dalmotor Co.,** 1347 Clay St., Santa Clara, Calif.



For more data circle MD-98, Page 211

Shunt or Series Motors

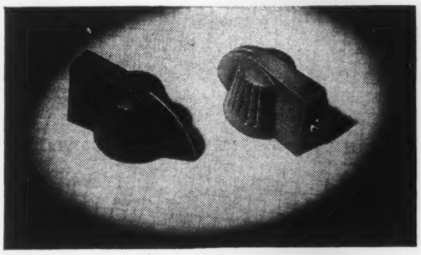
Model 512 motor is available in shunt and series wound types with either open or closed construction. Internal fan is optional and either porous bronze self-aligning sleeve bearings with oil reservoir or precision grease sealed ball bearings can be supplied. Other optional features include ten different gear units with wide choice of ratios; automatic governor controls for two, single or adjustable speeds; and automatic or manual motor protector. Base or face mounting is possible. Speed range for series type is 5000 to 15,000 rpm, rated at 1/10-hp continuous duty and 1/5-hp intermittent duty. Shunt motor is similarly rated at 1800 to 12,000 rpm and 1/12 and 1/6-hp. Units are available for standard ac and dc voltages. Made by **Howard Industries Inc.,** 1217 State St., Racine, Wis.



For more data circle MD-99, Page 211

Control Knob

Model 1431 control knob is fabricated from plastic, providing high insulation between shaft and operator and eliminating the need for a metal bushing. Made for electric and electronic equipment, knob is of the bar type and measures ¾-in. diameter at skirt and 1¼ in. along the bar. It fits shafts up to ¼-in. in diameter. A tapped hole with setscrew provides for locking on the shaft. Black and red knobs are available. Made by **Industrial Devices, Inc.,** 22 State Rd., Edgewater, N. J.

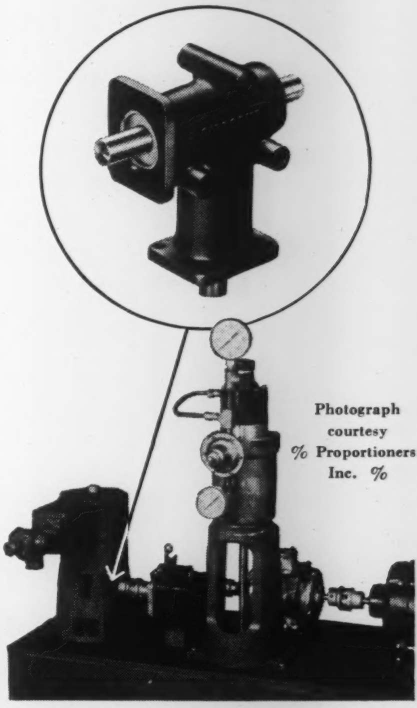


For more data circle MD-100, Page 211

Servo Gear Train

Available for any practical ratios from 1:1 to 7200:1, gear train has integral housed gearing, slip clutch and rotational limit stops. Slip torque is variable from ½-oz-in. to 20 oz-in.; limit stop may be set for data shaft (output) rotation from 10 deg to 40 turns. Unit may be mounted on any servo motor. Backlash is less than 10 min, and maximum starting torque is less than 0.05-oz-in. Ball bearing construction is employed throughout, although bushings may be used for higher ratios. Applications include simulation work,

What did they use before ANGLgear? TRADE-MARK



Photograph courtesy % Proportioners, Inc. %

In this pneumatically controlled regulator, an ANGLgear is used to convert horizontal power drive to a vertical axis.

Any engineer can design a right-angle power transmission. Most once did. Some, who have the time and budget, still do so. Others have discovered that ANGLgear—compact, versatile bevel gear—is ready made for virtually any right-angle application. Inexpensive, too... only $19.50 for the small model, $39.75 for the larger unit. Contact your distributor or write us for information.

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Now in Production The new BALDOR Baltric motors—smaller NEMA frames • more horsepower • less weight • streamcooled • totally enclosed • high performance • cool operation • simple design • compact contour rugged construction • protected ball-bearings • polyphase and single phase • integral and fractional ratings.

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Baldor TOTALLY ENCLOSED STREAMCOOLED MOTORS REQUIRE Less SERVICING

BALDOR STREAMCOOLED Motors are solidly enclosed, cooled by an outer-mounted fan in the bell-end. They cannot inhale dust, dirt, grit or metal particles. They require no dismantling for cleaning thus LESS servicing—no interruption of production.

Other features of BALDOR Motors include sealed ball-bearings which can be re-lubricated without removing end-plates. Corrosion-resistant inside and out. End plates interchangeable for vertical or bracket mounting. Each motor individually dynamically balanced. Standard NEMA dimensions.

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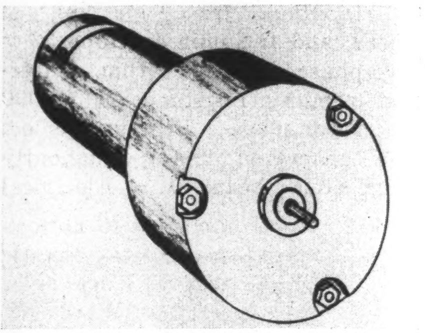
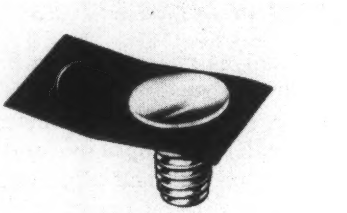


analog computers and automatic systems. Made by **Feedback Controls Inc.**, 503 Rhode Island Ave. N. E., Washington 2, D. C.

For more data circle MD-101, Page 211

Snap-In Fastener

Snapped into place just before final assembly, Quickey bolt makes possible nesting of sheet metal stampings without damage to stampings or fasteners. Bolt is attached to one of four styles of metal tab which snaps into keyhole-shaped opening in stamping.



Thread sizes are 10-24, ¼-20, 10-32, 8-32, ¼-28 or 5/16-18. Bolts will fasten material ranging in thickness from 0.04 to 0.134-in. Made by **United-Carr Fastener Corp.**, 31 Ames St., Cambridge 42, Mass.

For more data circle MD-102, Page 211

Linear Actuator

Switches, levers and other mechanical devices can be actuated electrically by No. 311 Safe-Return motor assembly, which converts power taken from the driveshaft of a high-speed fractional horsepower induction motor into lateral motion. This is done through a rack that can be made to travel as

(Advertisement)

You can simplify purchasing . . . improve design . . . speed production

with improved C-D-F DILECTO® laminates

Only C-D-F, the Continental-Diamond Fibre Company, makes Dilecto laminated plastic, just as only Cadillac makes a Cadillac. Dilecto is 50 different materials with more combinations and variations in desired properties than we can tell you here.

But Dilecto has three important qualities that you should think about if you buy, design, or machine laminated plastics.

DILECTO HAS HIGH MECHANICAL STRENGTH

Mechanical strength is frequently an important determining factor in the selection of an insulating material. Insulating parts used in large electrical power equipment are frequently bulky. The high mechanical strength of Dilecto helps reduce size-dimensions of insulating parts without danger of failure. Instruments, meters and small motors frequently require very small insulating parts which must withstand comparatively large mechanical stresses. Insulation for use in high frequency circuits should have a minimum bulk factor for minimum dielectric losses. Dilecto fulfills these requirements with a combination of high mechanical strength and low loss factor, characteristic of the better C-D-F electrical grades.

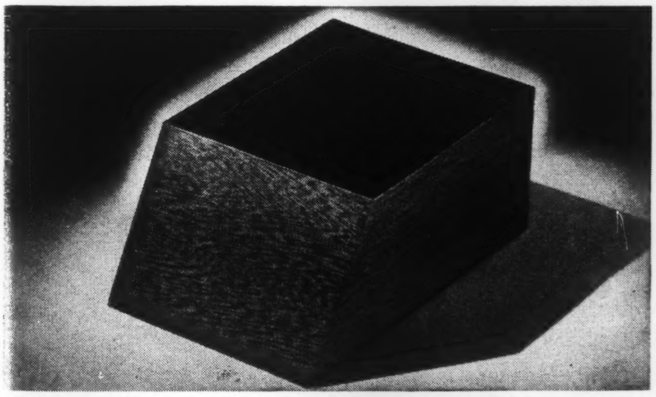
So C-D-F selects for your Dilecto insulation grade the correct, highest quality base material, paper, cotton, nylon, glass. These are used in combination with improved penetrating resins: Improved Phenolic, New Melamine, New Silicone, New Teflon, all synthetic, well polymerized resins.

Both the base and the resin are good insulators by themselves. But C-D-F sells them to you in an improved, practical form . . . Dilecto. Uniform sheets, tight tubes, strong rods, close tolerance machined and formed specialties, high bond strength metal clads.

Why does Dilecto combine so well mechanical strength with dielectric strength and dimensional stability? Because Dilecto is almost homogeneous, a true blend of resin and base.

DILECTO IS ALMOST HOMOGENEOUS

A poor laminate absorbs moisture at its edges, loses its insulating properties fast. Entrapped moisture and other volatiles within the cured structure causes inconsistent dielectric strength, with ultimate puncture and breakdown.



Punch press and bench saw operators know how much time and material is saved when the laminated plastic is *uniform* and *homogeneous* in nature like Dilecto.

DILECTO IS IMPROVED

Yes, C-D-F Dilecto is an improved laminated plastic, due to high standards and advances in resin and manufacturing techniques. It is watched by skilled workers in our modern plants, checked against rigid standards . . . C-D-F standards . . . by our quality control people. It is easy to machine, and the C-D-F shops are doing a booming business in specialties.

Table I—Typical Improved Phenolic Laminates

Commercial designation[a]	Resin	Filler	Improved properties	Improvement due to:
MEC-5	Phenolic	Nylon fabric	Insulation resistance; moisture resistance	Filler
XXHV-2[b]	Phenolic	Paper	High dielectric strength parallel to laminations	Resin and manufacturing technique
CRD	Phenolic	Cotton mat	Better machining	Filler
XXXP-26[b]	Phenolic	Paper	Insulation resistance; moisture resistance	Resin and manufacturing technique
C-92	Xylenol[c]	Cotton fabric	Alkali resistance	Resin
CF	Modified phenolic	Cotton fabric	Postforming	Resin

[a] All grades are Continental-Diamond Fibre Company.

[b] Resins have improved penetrating properties and the manufacturing techniques use these properties to provide better impregnation of the filler. Since thorough impregnation eliminates entrapped moisture and air, greater moisture resistance and better dielectric properties are attained. Manufacturing techniques also provide suitable temperature control during the curing stage to assure uniform quality and optimum property values in the finished laminate.

[c] Xylenol is essentially a dimethyl phenol.

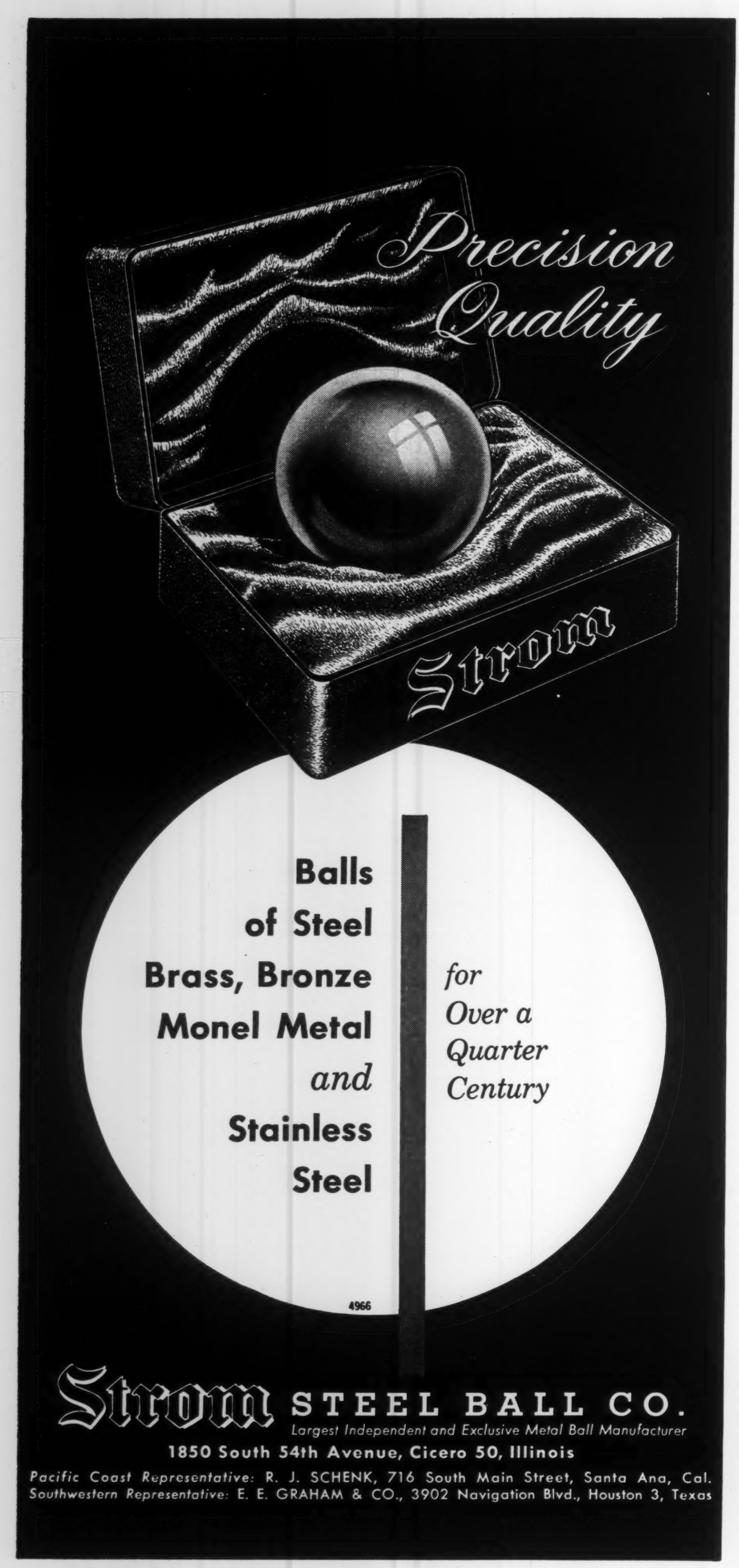
—from Electrical Manufacturing Article "Wider Design Opportunities with the NEW Phenolics", Part II.

The next time you think of laminated plastics, the name to remember is C-D-F Dilecto. The improved, high strength, uniform material that makes insulation buying and using more a science, less a puzzle. New grades, new applications, new savings are just part of the Dilecto success story. Look up the facts in Sweet's Design File, or write for catalog. Send us your blueprint for quotation . . . tell us your design dream . . . C-D-F wants to work with you.

CDF

Continental-Diamond Fibre

CONTINENTAL-DIAMOND FIBRE COMPANY
NEWARK 23, DELAWARE



Precision Quality

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Balls
of Steel
Brass, Bronze
Monel Metal
and
Stainless
Steel

*for
Over a
Quarter
Century*

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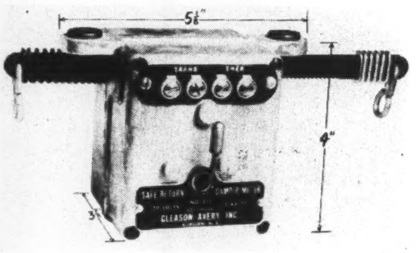
Strom STEEL BALL CO.
Largest Independent and Exclusive Metal Ball Manufacturer
1850 South 54th Avenue, Cicero 50, Illinois
Pacific Coast Representative: R. J. SCHENK, 716 South Main Street, Santa Ana, Cal.
Southwestern Representative: E. E. GRAHAM & CO., 3902 Navigation Blvd., Houston 3, Texas



much as 12 in. either right or left. Rack is returned to normal position by spring loading or a counterweight when the circuit is reenergized. Approximately 25 lb can be raised 4 in. in 30 seconds. Unit is available for 20 v or higher applications on 25, 50 or 60-cycle current. Made by **Gleason-Avery Inc.**, 29 Clark St., Auburn, N. Y.

For more data circle MD-103, Page 211

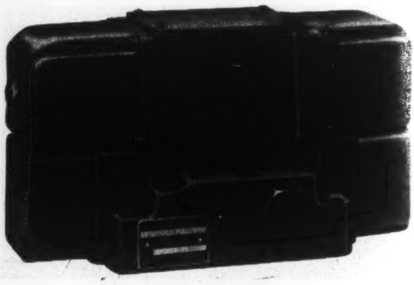
V-Belts

With neoprene carcass and cover, Super Gripbelts are oilproof, resistant to heat deterioration and have high strength in compression section. Cord construction minimizes stretch, stabilizes length and assures flexibility and lateral rigidity. A built-in static conducting compound makes them nonsparking and explosionproof. Four series of belts have pitch lengths ranging from 27 to 360 in. Made by **Browning Mfg. Co.**, 1940 Browning Dr., Maysville, Ky.

For more data circle MD-104, Page 211

Four-Way Valve

Solenoid-controlled, pilot-operated four-way valve is available in ½ and ¾-in. sizes for volumes up to 20 gpm and operating pressures up to 2000 psi. It is made in QF



SPEED KING

SOLENOID PILOT OPERATED CONTROL VALVE

by VALVAIR

DESIGNED AND BUILT TO J. I. C. STANDARDS

- **A Hefty Assist to Automation**
- **Fully Enclosed**
- **Integral Junction Box**

The Valvair line broadens again — with Speed King's exclusive features. All parts are totally enclosed. The Speed King will operate submerged in water or buried in sand. Simplicity! — only two moving parts. Molded coil — no wear or shorting out. 20,000,000-cycle life and more. Speed King is industry's most rugged and compact valve.

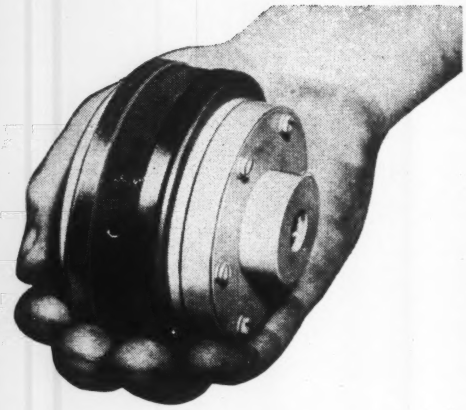
Other features: for pressures from 35 to 200 p.s.i. pneumatics, hydraulics, vacuum; complete line—2-way, 3-way, 4-way and 4-way-5-port (2-pressure) models; foot or sub-base (manifold) mounting; pipe sizes —¼", ⅜", ½", ¾", and 1".

Ask for Bulletin "D-5".

Representation in: **BALTIMORE • BIRMINGHAM • BOSTON BROOKLYN • BUFFALO • CHARLESTON, W. VA. • CHICAGO CLEVELAND • CRANFORD, N. J. • DAYTON • DENVER DETROIT • EUREKA, CALIF. • GLENSIDE, PA. • HOUSTON KANSAS CITY, MO. • LOGANSPORT, IND. • LOUISVILLE MILWAUKEE • MINNEAPOLIS • PASADENA • PITTSBURGH PORTLAND • ST. LOUIS • SAVANNAH • SEATTLE MONTREAL • TORONTO • VANCOUVER**

VALVAIR CORPORATION *Affiliate: Sinclair-Collins Valve Company*
953 BEARDSLEY AVE., AKRON 11, OHIO

Rely Upon **Valvair** DIVERSATILITY

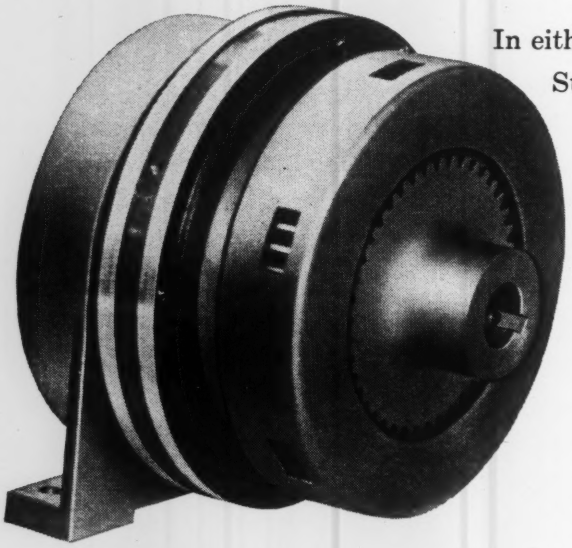


Be Sure with a Matched-to-the-Machine

STEARNS MAGNETIC CLUTCH

On many machines, a standard magnetic clutch does the job.

On others, however, a special custom-made unit is needed for the most profitable results.



In either case, you're right with Stearns — because this pioneer in magnetic equipment builds both.

Here are important reasons why Stearns magnetic clutches provide positive dependable control on such a wide variety of applications.

- *Torque range from .4 to 30,000 lb. ft.*
- *Low inertia — fast, smooth engage and disengage. Split shaft, through shaft, two speed drives, forward and reversing drives — other special applications.*
- *Quiet and cool running. No metal-to-metal contact, no sparking.*
- *Automatic or manual control.*
- *No toggles, yokes, shifters.*
- *Simple adjustment.*

Let Stearns' design and engineering experience work for you. Consult your Sweet's Product Design File or write for bulletin 226-C-2.

1083

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

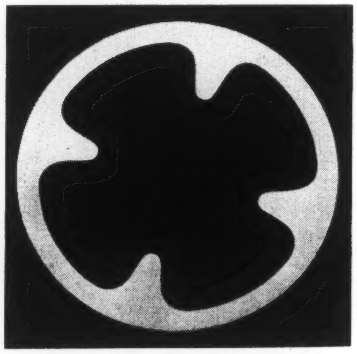
STEARNS MAGNETIC, INC. 692 S. 28th St., Milwaukee 46, Wis.

QM and QJ series in two-position (no spring), spring-centered and spring-offset models. Solenoid covers are gasketed to protect against moisture and dirt, and built-in terminal box offers easy access for installation and service. Two-position model offers optional spool locking device to prevent spool shifting due to vibration or pressure in drain line. Valves can be converted from one model to another and are available with full selection of spool types, throttle chokes to control shifting speed and in a complete voltage range. Made by **Double A Products Co.,** Manchester, Mich.

For more data circle MD-105, Page 211

Extruded Steel Tubing

Extruded heat exchanger stainless steel tubing has integral internal fins to increase heat transfer area. Similar extruded tubular products with either internal or external finning can be produced from a variety of steels in a limited size range. Made by Tubular Products Div., **Babcock & Wilcox Co.,** Beaver Falls, Pa.



For more data circle MD-106, Page 211

Temperature Detector

Hermetically sealed electrical resistance temperature detector is designed for use with temperature recording, indicating and control equipment requiring fast response. Detector has an exponential time constant of 0.8-second or better in an agitated water bath. Sealed

KLOSD DRIP-PROOF
CONSTANT NORMAL SPEED MOTORS
KLOSD-TITE FAN-COOLED
CONSTANT NORMAL SPEED MOTORS
STERLING MOTOR
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MORE HORSEPOWER...
IN LESS SPACE...

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NEW NEMA MOUNTING DIMENSIONS

PLUS...

THESE 10 STERLING ADVANCED DESIGN FEATURES

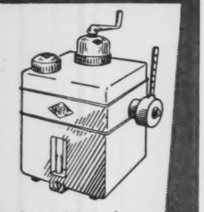
- Over 50% less inactive space
- Protected construction
- Greater bearing protection
- Advanced design terminal box
- Heavy duty ball bearings
- Herringbone rotor
- Direct-through ventilation
- Increased efficiency and performance
- Stator windings of advanced design
- Improved insulation

WRITE FOR NEW BULLETIN NO. E-424-A

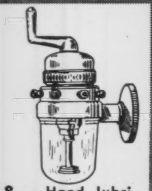
Sm **STERLING** ELECTRIC MOTORS Sm

New York City 51; Chicago 35; Los Angeles 22; Hamilton, Ont., Canada; Santiago, Chile

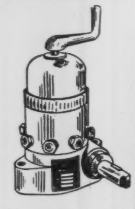
HART CENTRALIZED LUBRICATION **MAKES THIS POSSIBLE**



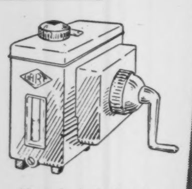
E.RP — Ratchet drive from 1-8 outlets with reservoir; capacity 1,75 liters



CB.R-8 — Hand lubricator with transparent reservoir; capacity 0,1 liter from 1-8 outlets



E.OR — Rotary drive from 1-8 outlets without reservoir



CA-16 — Hand lubricator with reservoir; capacity 1 liter from 1-16 outlets

- To control the quantity and time interval of the lubricant
- To prevent waste of lubricant
- To reduce unproductive labor
- To permit continuous machine operations with no interference to production
- To reduce maintenance costs
- To remove accident risk from hand oiling

The outstanding advantages offered by the Hart centralized lubrication systems result in improved equipment performance and increased quality of the product.

There are two modern systems from which to choose a variety of Hart lubricators.

- Mechanically operated (Type E)
- Manually operated (Type C)

Let us furnish further information concerning the system best suited to your equipment.

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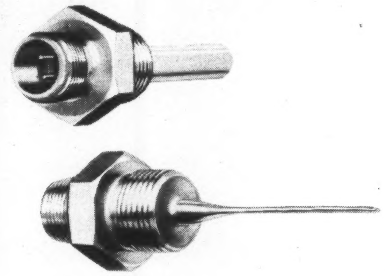
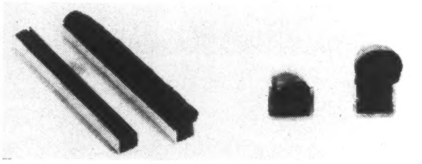


in a stainless steel housing with a glass-to-metal sealed base through which the electrical connection is made, it offers maximum resistance to corrosion and is not affected by most forms of destructive radiation. Useful temperature range is −70 to 200 C, and temperature accuracy is ±1 per cent or better in mid-scale region. Sensing element is a nickel winding with a basic resistance of 90.38 ohms at 0 C. Made by **Thomas A. Edison Inc.,** Instrument Div., West Orange, N. J.

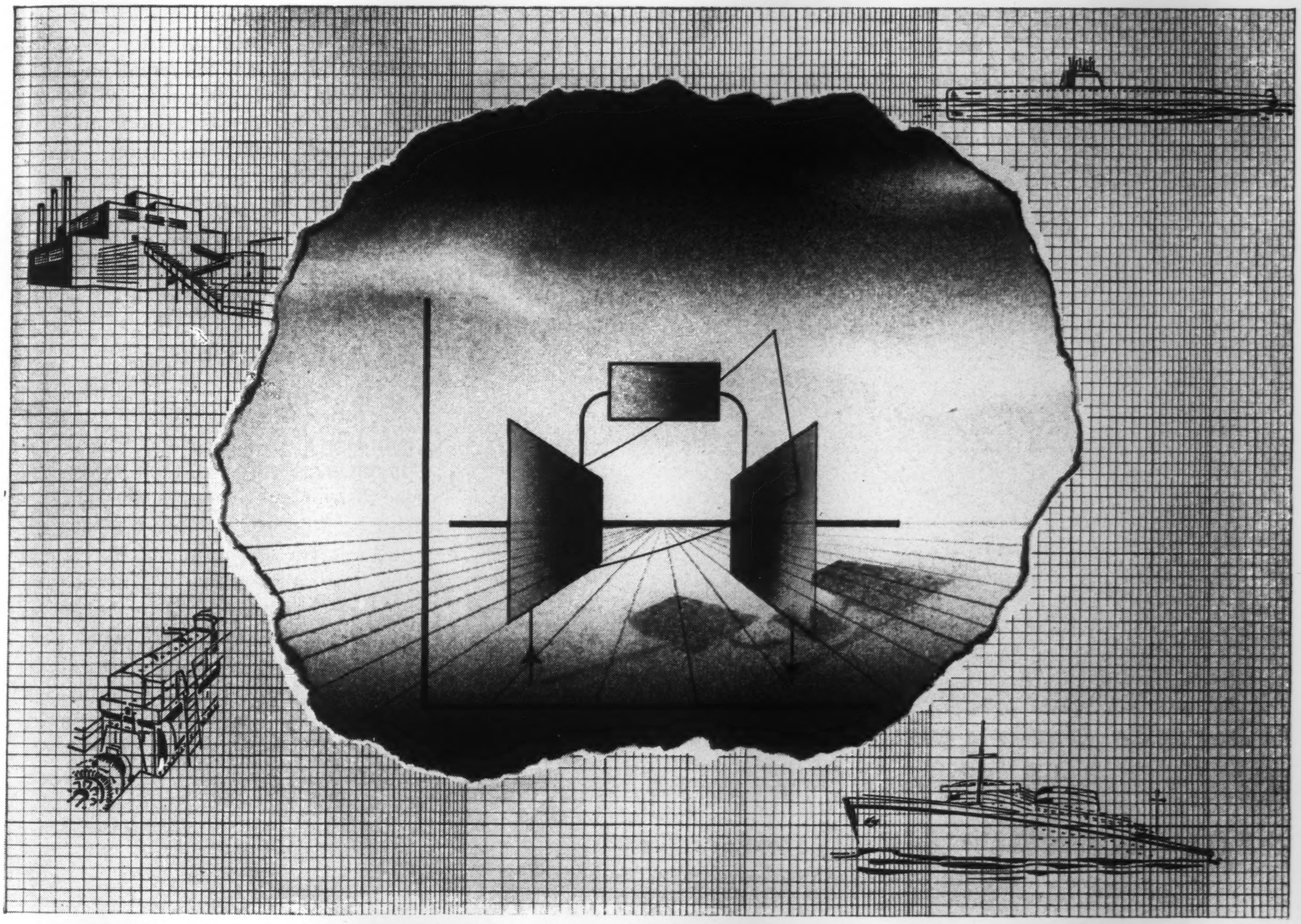
For more data circle MD-107, Page 211

Extruded Rubber Sealer

Applied in the form of a flexible rubber strip, EC-1209 extruded rubber based sealer cures and expands when heated to form a uniform gasket-like material between metal surfaces. It can be used to seal out water, dust and dirt, as a cushion to prevent rattles and squeaks, and to seal seams of nonuniform width. Amount of volume increase depends on time and temperature used in the curing process. Curing for 40 minutes at 250 F will produce a swell of 70 to 80 per cent, while a 15-minute cure at 350 F will cause swelling to nearly 125 per cent. It remains flexible at −20 F and has long life at 150 F. Curing can take place in paint drying and baking ovens as it does not require a separate heating cycle. Sealer also provides



NEW HORIZONS IN ENGINEERING



What has this symbol to do with *the future of power?*

Plenty. You'll recognize this symbol as a conventional thermodynamic cycle. But there's nothing conventional in the new developments in thermodynamics at I-T-E. These revolutionary developments may well usher in new horizons in the field of power generation.

Development work in thermodynamics is only one of the many projects on which the Special Products Division of I-T-E is engaged. Other challenging assignments include development and fabrication of a number of close-tolerance devices for extreme service conditions.

Whether your problem is new development to performance specifications, or fabrication with new and hard-to-work alloys, you'll want to know how this unique organization can help you.

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design, development and fabrication

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manufacture of major hot-end components

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advanced fabricating techniques

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proven welding, forging, forming, spinning techniques with this hard-to-work metal

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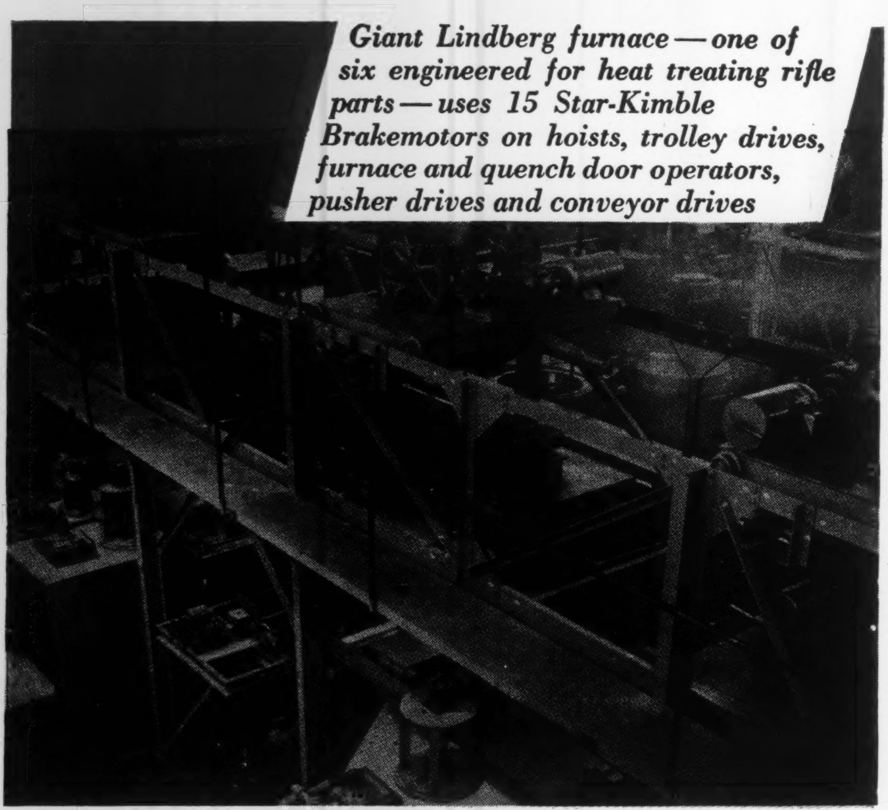
Progress through Problem Solutions

SP 10.3



Giant Lindberg furnace — one of six engineered for heat treating rifle parts — uses 15 Star-Kimble Brakemotors on hoists, trolley drives, furnace and quench door operators, pusher drives and conveyor drives

Wherever brakes are required on furnaces,

Lindbergh Engineering Co. uses Star-Kimble Brakemotors

BECAUSE

1 Installation costs are lower. Motor and brake mounted on a single sturdy shaft. NO ALIGNMENT PROBLEMS.

3 Maintenance costs are lower. Brake wear is extremely low — result of extra-large braking area and use of wire-reinforced brake linings.

2 [illegible] Brakemotor stops are split-second in timing—maintain their precision because of low, even brake wear.

Those are the reasons why Lindberg uses Star-Kimble Brakemotors *exclusively* wherever brakes are needed. When service calls for fast, smooth stop-start cycles — *repeated millions of times* — Star-Kimble Brakemotors will do the job with little or no maintenance attention.

For complete information, write for Bulletin B-501-A.

Standard and special motors of all types, 1 to 125 hp; generators and motor-generator sets, 1 to 100 kw; marine motors, ½ to 125 hp.

Star-Kimble

MOTOR DIVISION
Miehle Printing Press and Mfg. Co.

201 Bloomfield Avenue Bloomfield, New Jersey

New Parts

a good seal mechanically even if heat is not used. Normal packaging is in 30-in. lengths of ¼-in. diameter material, with each box containing 810 linear feet. Made by Adhesives and Coatings Div., **Minnesota Mining & Mfg. Co.,** 423 Piquette Ave., Detroit 2, Mich.

For more data circle MD-108, Page 211

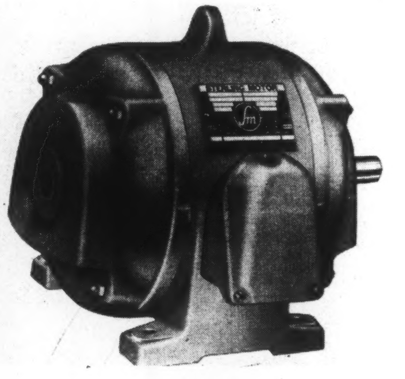
All-Purpose Adhesive

A quick-setting and heavy-bodied rubbery material, Placco 1000 all-purpose adhesive fastens heavy objects to smooth surfaces. Under test, a 2-in. square bond withstood pull of over 300 lb at 300 F. Material can also serve as protective coating because it is waterproof, heat and weather resistant, flexible, corrosion resistant, noninflammable and nontoxic. It gives off no fumes and will not contaminate foodstuffs. Developed by **Pioneer Latex and Chemical Co.,** Middlesex, N. J.

For more data circle MD-109, Page 211

NEMA Rerated Motors

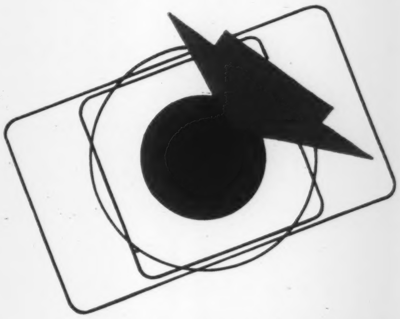
Made in frame sizes 182 and 184, Klosd normal speed electric motors incorporate latest NEMA standards specifying greater horsepower for size. Motors have diagonal cover type terminal boxes that can be rotated 360 degrees and set in any desired position. Moisture-resistant labyrinth seal on pulley end protects both open and fan-cooled types; improved brackets give greater protection to windings; and improved insulation offers better moisture and heat re-



O-M CYLINDERS

air • hydraulic

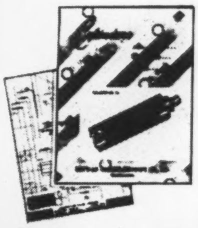
fit where others won't!



O-M Cylinders require up to 1/3 LESS INSTALLATION SPACE than conventional cylinders of the same bore, because O-M's *Special Interlocking Mechanism* eliminates projecting tie rods and bulky end caps. In addition, the "O. D." of O-M Cylinders can be easily and accurately machined for cartridge mounting within your equipment.

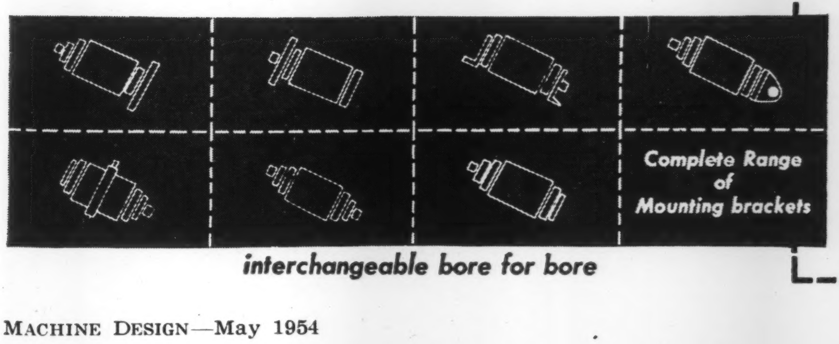
O-M Special Interlocking Mechanism also assures perfect alignment giving O-M the lowest coefficient of friction of any cylinder. Thus, O-M Cylinders are smoother operating at low or high speeds regardless of length of stroke. Easily removed, inspected, repaired, replaced. Completely interchangeable parts.

Available in a full range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. *14-day delivery on most sizes.*



Write today for FREE catalog and complete set of ½- and ¼-scale templates showing all cylinders and mounting brackets.

mail coupon now!



Complete Range of Mounting brackets

interchangeable bore for bore

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The Problem of Driving the Pump from a Reversing Shaft without Changing Direction of Flow or Port Positions

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AUTOMATIC REVERSING PUMPS
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CATALOG NO. 105
TUTHILL PUMP COMPANY

New Tuthill Catalog No. 105 Provides the Facts You Need on Automatic Reversing Pumps

How to lubricate reversing machinery! How to provide coolant or hydraulic power when the pump must be driven from a reversing shaft! How to insure pump flow in the proper direction on machinery which must be shipped without knowing the ultimate direction of the driving members!

The answers to questions like these are presented in this new Catalog No. 105 on Tuthill Automatic Reversing Pumps. Through a unique feature developed by Tuthill, these pumps can be driven in either direction of rotation without changing direction of flow or port positions. The wide range of types, sizes, and pressures makes these pumps readily adaptable to your requirements. Capacities up to 200 g.p.m. and pressures to 400 p.s.i.

Write for your copy of Catalog No. 105 today

TUTHILL PUMP COMPANY
Dependable Rotary Pumps since 1927
939 East 95th. St., Chicago 19, Ill.

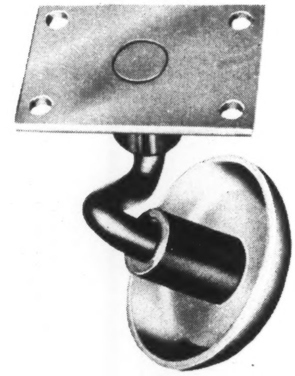
Canadian Affiliate: Ingersoll Machine & Tool Co., Ltd.
Ingersoll, Ontario, Canada

sistance and mechanical strength. Made by **Sterling Electric Motors Inc.,** 5401 Telegraph Rd., Los Angeles 22, Calif.

For more data circle MD-110, Page 211

Steel Ball-Bearing Caster

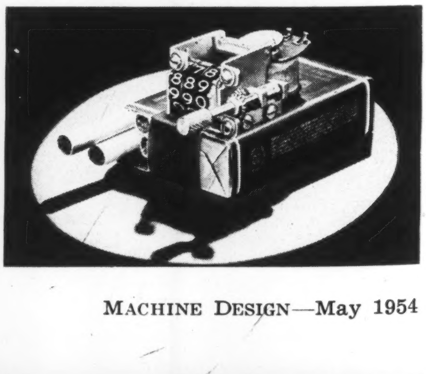
Nonjamming steel caster employs a curved axle with dual ball-bearing sockets to provide free starting from any position and to minimize vibration and shock on rough surfaces. Caster will not lock under maximum rated load. It is fabricated from high strength alloy steel with rust resistant finish and is available in standard $1\frac{1}{2}$ and $2\frac{1}{2}$-in. wheel diameters with either welded or screw type bearing plate. Made by **Rolawheel Co.,** 1757 W. Grand Ave., Chicago 22, Ill.

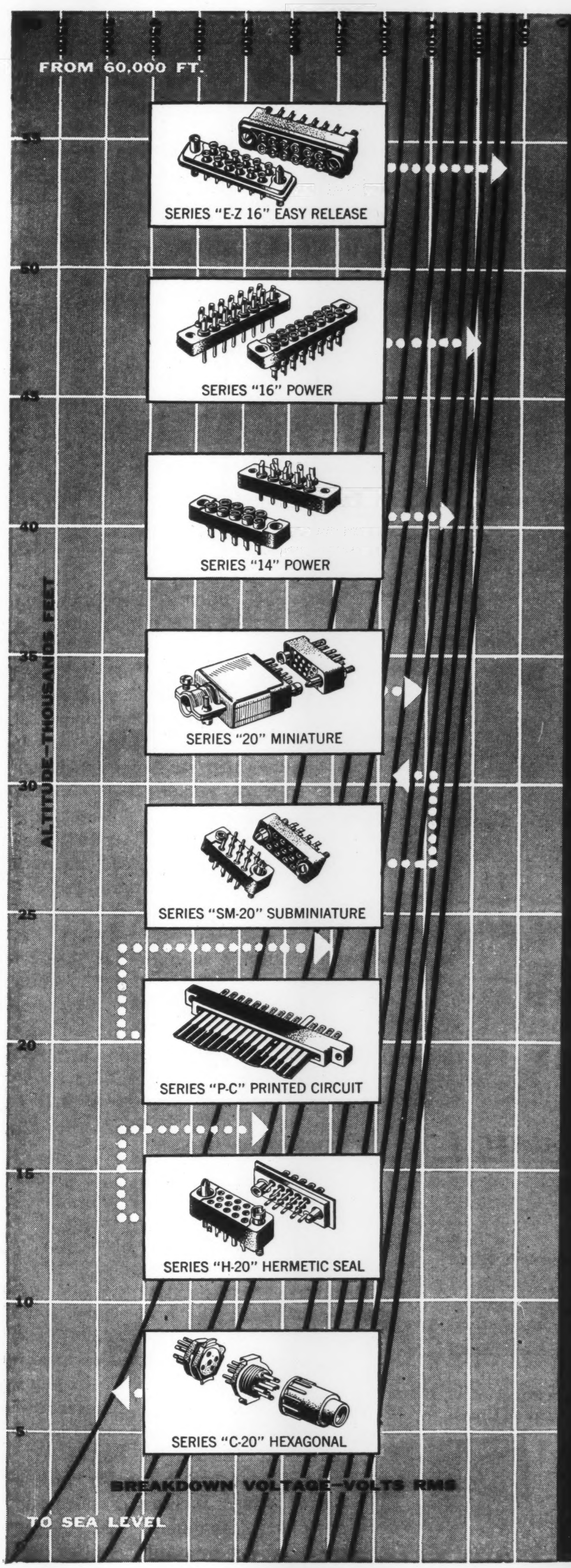


For more data circle MD-111, Page 211

Digital Counter

Nylon ratchet movement makes possible a high-speed, lightweight miniature counter. The sensitive tripping mechanism allows the use of electrical, pneumatic, hydraulic





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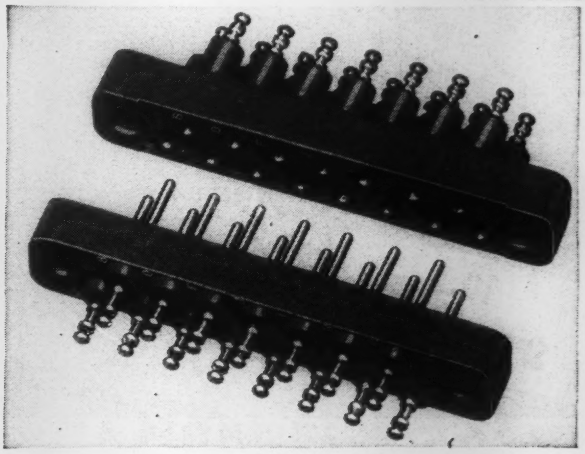
precision
Continental Connectors*

simplify your connector problems

ACTUAL SIZE



Power Connectors

with turret terminals or solderless taper pin wiring

Heavy-duty types for applications requiring larger current capacities of #14 and #16 AWG wire. Available with 7, 10, 15, 18 or 20 contacts, and insulating material in choice of Melamine, Plaskon-Alkyd, or Diallyl Phthalate. Turrets on the socket and pin contacts permit easy wrap-around wiring. No soldering is necessary with the taper pin wiring type.

Submit your design problem to us, or send for Engineering Data Sheets on your company letterhead. Write or wire to Department MDT-5 DeJUR-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, New York.

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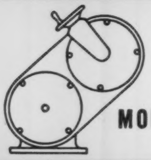
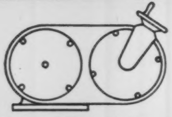
*WORLD'S LARGEST MANUFACTURERS OF MINIATURE PRECISION CONNECTORS

REEVES

Fractional HP Motodrive

NEW!
REEVES
10:1
SPEED RANGE





NEWEST DESIGN FOR VARIABLE SPEED

112 ASSEMBLIES

to choose from— engineered to your exact requirements!

CHECK ALL THESE NEW, REEVES FEATURES

1 New redesigned, more compact drive gives you speeds from 3 to 4660 RPM . . . speed ranges from 10 to 1!

2 New "all-position," 14-turn handwheel gives operator sensitive, minutely-accurate speed control from a position most convenient for the installation!

3 New "all-position" output shaft permits driving in any direction—horizontal or vertical down!

4 New spiral groove lubrication with exclusive overflow outlet provides complete lubrication of all sliding surfaces for trouble-free operation at all times!

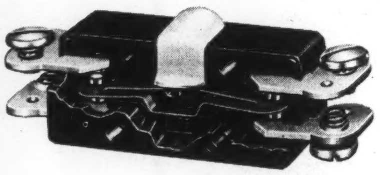
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Send Today for Complete Information!
Specify Bulletin H7-M543.

or mechanical information insertion. Device can be used to count machine output or adapted to measure fluid volume and to other industrial, scientific and aircraft applications. Made by **Mueller Laboratory,** 239 W. Maple Ave., Monrovia, Calif.

For more data circle MD-112, Page 211

Snap-Action Switch



General purpose switch for limit, control, safety and interlock applications is available in 24 different models, including eight reset switch models; single-pole, single-throw, normally open or closed; single-pole, double-throw, normally open or closed. Housings can be splashproof die-cast, general purpose or hermetically sealed. If not exposed to dirt, dust or lubricants, switch can be used without metal housing. Positive rapid snap action is independent of actuation speed. Switch has self-aligning springs for desired wiping action of contacts. Double break contacts provide two separate circuits. Rated at 10 amp at 125 or 250 v ac or 30 v dc, switch measures 1¼ x ½ x ½-in. Made by **Electro-Snap Switch & Mfg. Co.,** 4218-30 W. Lake St., Chicago 24, Ill.

For more data circle MD-113, Page 211

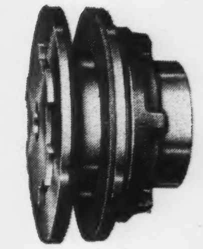
Nickel Silver Strip

Precision rolled to close tolerances and to thin gages and foils, 18 per cent nickel silver is custom rolled in strip from 0.0005-in. thickness, to 6-in. widths, to tolerances of ±0.0001-in. The tough, highly malleable and ductile metal is resistant to corrosion, wear and fatigue. Uses include diaphragms; springs; component and contact material on commutators for low-

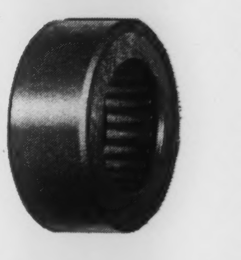
Morse Double Pitch Chain . . . Power Transmission Series

Morse Standard and Double Pitch Roller Chain, both available with attachments. Also available with bent or straight attachment plates, one or two attachment holes, standard or large rollers. Pitch sizes from 1" to 2½".

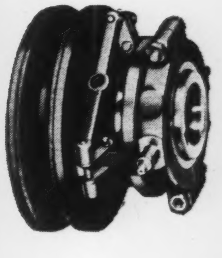
Morse Double Pitch Chain . . . Conveyor Series



Torque-Limiter . . . Slip-type friction device for automatic overload protection.



Morse Full-Complement Cam Clutch . . . (series-200) stops reverse shaft rotation; prevents rollback of conveyor feed mechanism.



Morse-Rockford Over-Center Friction Clutches, 4 basic types, hp ranges from .57 to 1.7 per 100 rpm.

How Morse can help you solve your automation problems right now

Since it is true that the advantages of automation depend upon the accuracy and non-stop qualities of machinery, the need for power transmission products which are dependable, smoothly operating, practicable and economical becomes more apparent.

It's true, too, that the change from manually operated to fully automatic machines on existing production lines must be feasible and economical. And that's where Morse comes in.

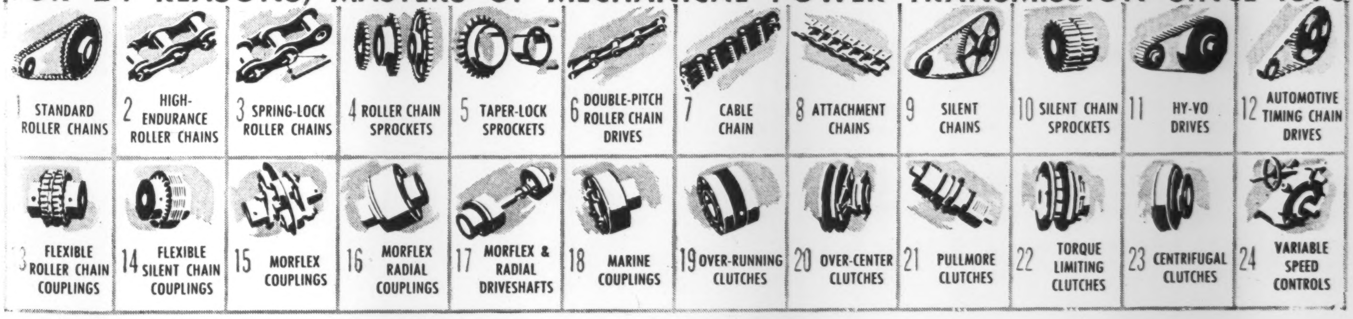
Morse Chain Company offers you a complete line of power transmission products (see below). There is a type for almost every need, whether it's positioning, timing, conveying, or power transmission, with a wide range of sizes within each type.

Furthermore, Morse products can be secured easily —for the most part, off the shelf of your distributor. **It costs no more** to deal with the leading manufacturer of quality power transmission products. And the Morse extensive line is one long recognized for its precision, durability and economy.

Why not write today for more information on how you can benefit through the use of the Morse product line now, in this age of automation. MORSE CHAIN COMPANY, 7601 Central Avenue, Detroit 10, Michigan.

MORSE
PRODUCTS OF BW BORG-WARNER
MECHANICAL POWER TRANSMISSION PRODUCTS

FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893



1 STANDARD ROLLER CHAINS
2 HIGH-ENDURANCE ROLLER CHAINS
3 SPRING-LOCK ROLLER CHAINS
4 ROLLER CHAIN SPROCKETS
5 TAPER-LOCK SPROCKETS
6 DOUBLE-PITCH ROLLER CHAIN DRIVES
7 CABLE CHAIN
8 ATTACHMENT CHAINS
9 SILENT CHAINS
10 SILENT CHAIN SPROCKETS
11 HY-VO DRIVES
12 AUTOMOTIVE TIMING CHAIN DRIVES
13 FLEXIBLE ROLLER CHAIN COUPLINGS
14 FLEXIBLE SILENT CHAIN COUPLINGS
15 MORFLEX COUPLINGS
16 MORFLEX RADIAL COUPLINGS
17 MORFLEX & RADIAL DRIVESHAFTS
18 MARINE COUPLINGS
19 OVER-RUNNING CLUTCHES
20 OVER-CENTER CLUTCHES
21 PULLMORE CLUTCHES
22 TORQUE LIMITING CLUTCHES
23 CENTRIFUGAL CLUTCHES
24 VARIABLE SPEED CONTROLS

need information on

metals?

reach for your Product Design File

Product Design File
S
1954
materials 1
electrical parts 2
mechanical parts 3
techniques and services 4
Sweet's Catalog Service

"... a great time-saver"

These manufacturers' catalogs are instantly available in Section 1A of your Product Design File:

- Allegheny Ludlum Steel Corp.
- Aluminum Co. of America
- Ampco Metal, Inc.
- Apollo Metals Works
- Armco Steel Corp.
- Babcock & Wilcox Co.
- Baker & Co.
- Beryllium Corp.
- Bethlehem Steel Co.
- Bishop, J., & Co.
- Brooks & Perkins, Inc.
- Bundy Tubing Co.
- Carpenter Steel Co.
  - stainless steel
  - steel tubing
- Dow Chemical Co.
- Fairmont Aluminum Co.
- General Electric Co.
- Globe Steel Tubes Co.
- Great Lakes Steel Corp.
  - N-A-X Alloy Div.
- International Nickel Co.
- Jones & Laughlin Steel Corp.
- Kaiser Aluminum & Chemical Sales Inc.
- Michigan Steel Tube Products Co.
- Mueller Brass Co.
- Ohio Seamless Tube Co.
- Republic Steel Corp.
- Republic Steel Corp.
  - Steel & Tubes Div.
- Revere Copper & Brass Inc.
- Reynolds Metals Co.
- Rigidized Metals Corp.
- Rochester Products Div.
  - General Motors Corp.
- Rodney Metals, Inc.
- Sharon Steel Corp.
- Standard Tube Co.
- Superior Tube Co.
- U. S. Steel Corp.
- Washington Steel Corp.
- Weirton Steel Co.
- Werner, R. D., Co.

In other sections of the File you will find additional catalogs containing useful information on product forms, characteristics, performance and use.

Sweet's Catalog Service

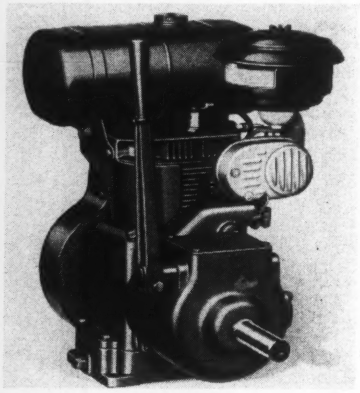
Division of
F. W. Dodge Corporation
119 West 40th Street,
New York 18, N. Y.

current purposes; stamped, drawn or spun articles; trim and electrical appliances. Available from Industrial Div., **American Silver Co. Inc.**, 36-07 Prince St., Flushing 54, N. Y.

For more data circle MD-114, Page 211

Air-Cooled Engine

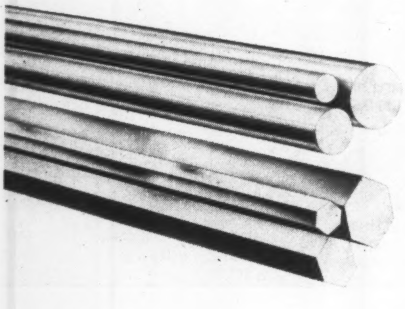
Model K160 air-cooled engine, now available with hand clutch, is designated as model K160C. Unit is single cylinder, four-cycle type equipped with oil bath air cleaner, ball bearings, oil bathed fly-ball governor, fuel filter and silencer muffler. It has 1¼-gal fuel tank. Engine provides 6.6 hp at 3600 rpm, 6.3 at 3000, 5.1 at 2400, and 3.7 at 1800 rpm. Made by **Kohler Co.**, Kohler, Wis.



For more data circle MD-115, Page 211

Leaded Steel Bar

Now made in smaller and larger sizes than previously available, Super LaLed is a free-machining open hearth leaded steel bar which machines at speeds nearly as high as those for brass. It contains about ¼-per cent lead and nearly ½-per cent sulphur and can be used to replace brass where corrosion is not a factor and where brass has been used primarily because of its machinability. It is available cold drawn in rounds ¼ through 3 in. in diameter and hexagons ⅜ through 3 in. Made by **LaSalle Steel Co.**, 1412 150th St., Hammond, Ind.



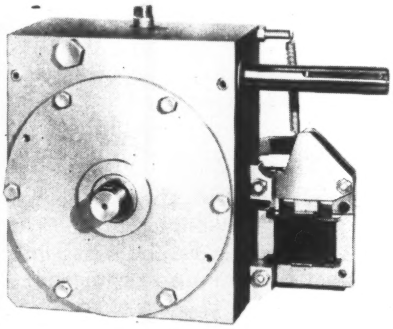
For more data circle MD-116, Page 211

Plastic Tubing

Machinable heavy wall tubing possessing physical and chemical properties comparable to standard Saran tubing is available in 3-ft lengths with 2⅝-in. OD and 1½-in. ID. Tubing is tough, flexible and abrasion resistant and has high bursting strength as well as good resistance to corrosive liquids. It is resilient and will withstand repeated vibration. Made by **Pyramid Plastics Inc.**, 554 W. Polk St., Chicago 7, Ill.

For more data circle MD-117, Page 211

Solenoid-Controlled Clutch

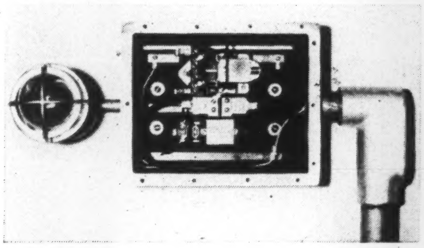


Engagement and disengagement of this clutch is controlled by a switch. Clutch can be made to perform one revolution, fractions of a revolution or multiple revolutions, the minimum being ¼-revolution, with increases in multiples of 1/64-revolution. Characteristics include instant starting, positive stopping and a built-in worm-gear type speed reducer with a 20:1 and 40:1 reduction. Variations include single or double output shaft extension, left or right-hand input and ratings from fractional to hp. Made by **Anderson Bros. Mfg. Co.,** 1907 Kishwaukee St., Rockford, Ill.

For more data circle MD-118, Page 211

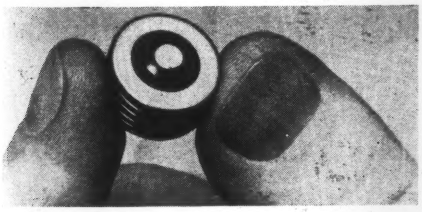
Overload Controller

Designed for use on machines requiring overload protection, improved controller has instant magnetic action. Dual control contacts provide a means of stopping a prime moving machine, its auxiliary equipment, or both. Feeding stops instantly if prime mover stops. Enclosed in a cast aluminum dust and waterproof housing, unit is available for motors of all voltages and up to 100 hp. Made by **Ralph C. Gardner,** 1 Lima Rd., Fort Wayne 8, Ind.



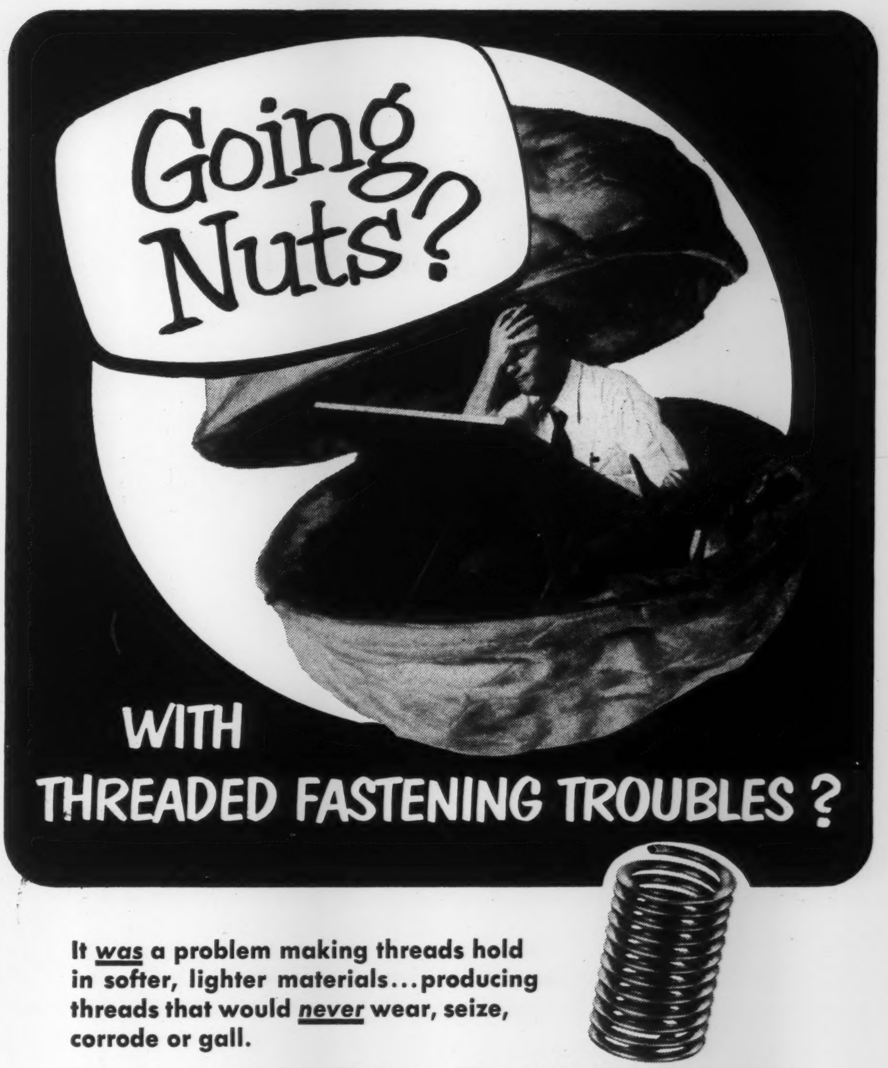
For more data circle MD-119, Page 211

Button Type Switch



Set of movable contacts hermetically sealed in an accordion-like diaphragm of this "button" switch will perform at any altitude, even in a vacuum, with a minimum of pitting. Enclosure is filled with helium gas under pressure. Device can be used under conditions of dirt and dust or in presence of combustible materials and can be produced in any size. Made by **Slater Electric & Mfg. Co.,** 56th St. and 37th Ave., Woodside, N. Y.

For more data circle MD-120, Page 211


Going Nuts?
WITH
THREADED FASTENING TROUBLES ?

It *was* a problem making threads hold in softer, lighter materials...producing threads that would *never* wear, seize, corrode or gall.

But not since ***Heli-Coil**** Screw Thread Inserts! They make weak threads strong and *perfect*. And they save you weight, space and money because you can use fewer, smaller, shorter fastenings, smaller bosses and flanges.

When it comes to threaded fastenings, thousands of manufacturers throughout the world use ***Heli-Coil*** Screw Thread Inserts to answer their design, manufacture and field service problems. Send today for full information, specifications and samples. And a ***Heli-Coil*** Thread Engineer will be happy to assist at your request.

Heli-Coil Inserts conform to official Military Standards MS-122076 (ASG) through MS-124850 (ASG) and others.

* Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
125 SHELTER ROCK LANE, DANBURY, CONN.

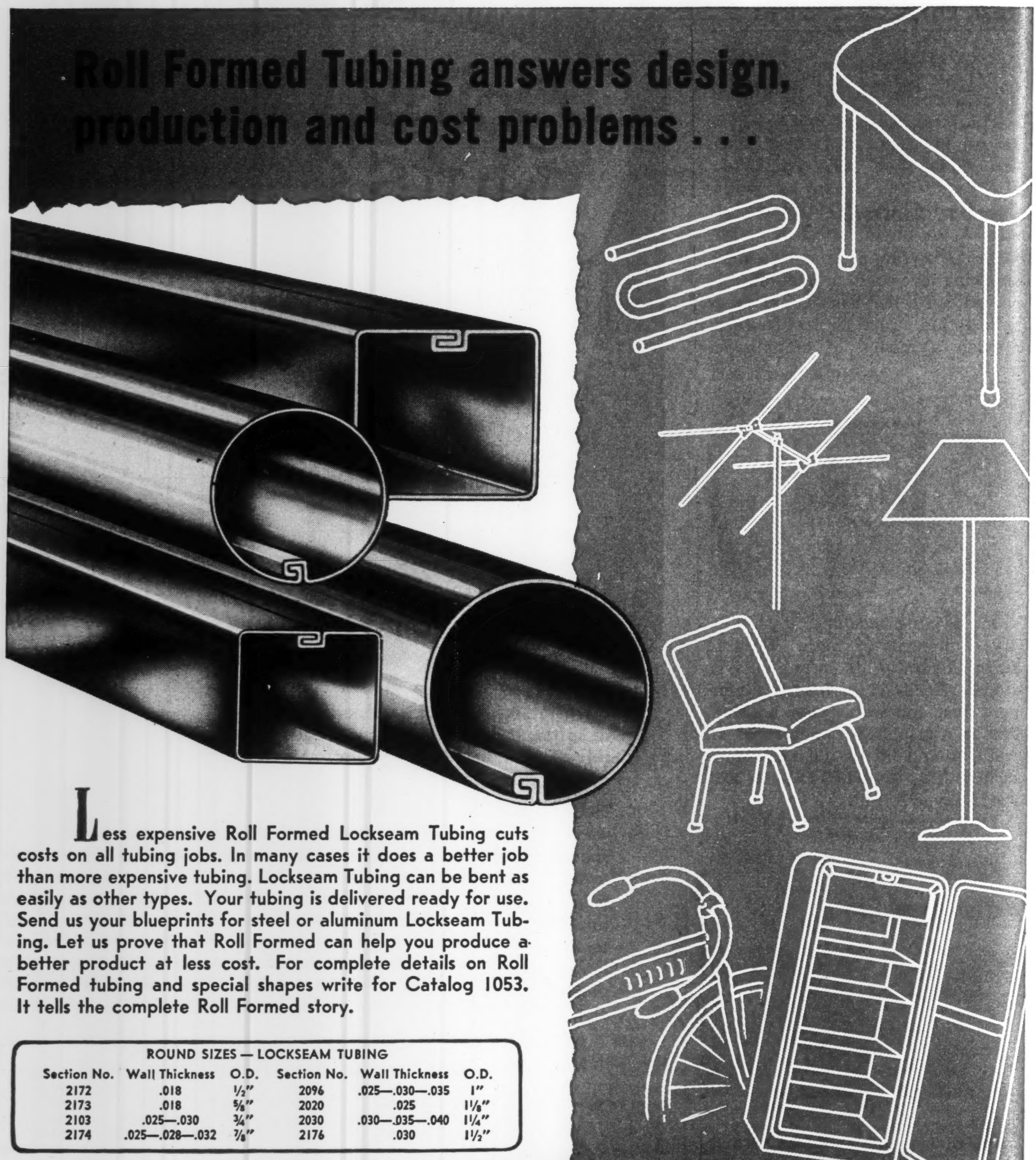
☐ Please send samples and Bulletin 689—Military Standards Sheets.
☐ Please have a *Heli-Coil* Thread Engineer call.
☐ Send samples and Handbook 652, a complete design manual.

NAME________ TITLE________

COMPANY________

ADDRESS________

CITY________ ZONE____ STATE________ 2711



Roll Formed Tubing answers design, production and cost problems . . .

Less expensive Roll Formed Lockseam Tubing cuts costs on all tubing jobs. In many cases it does a better job than more expensive tubing. Lockseam Tubing can be bent as easily as other types. Your tubing is delivered ready for use. Send us your blueprints for steel or aluminum Lockseam Tubing. Let us prove that Roll Formed can help you produce a better product at less cost. For complete details on Roll Formed tubing and special shapes write for Catalog 1053. It tells the complete Roll Formed story.

ROUND SIZES — LOCKSEAM TUBING

Section No.	Wall Thickness	O.D.	Section No.	Wall Thickness	O.D.
2172	.018	½"	2096	.025—.030—.035	1"
2173	.018	⅝"	2020	.025	1⅛"
2103	.025—.030	¾"	2030	.030—.035—.040	1¼"
2174	.025—.028—.032	⅞"	2176	.030	1½"

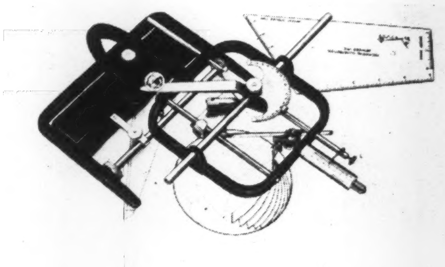
ROLL FORMED PRODUCTS COMPANY

MAIN OFFICE AND PLANT
3754 OAKWOOD AVENUE • YOUNGSTOWN, OHIO

ENGINEERING DEPARTMENT EQUIPMENT

Drawing Machine

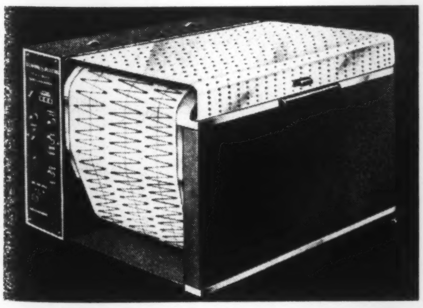
Circular drawing machine makes accurate pictorial drawings in less time than is required to make plan view drawings. Two settings establish the major and minor diameters, enabling the user to draw mathematically precise ellipses in any ratio by degrees or from points on a drawing. Repeated and related ellipses on the same axis can be made because of instrument's rolling parallel action. This characteristic permits the making of exploded views. Made by **Charles Bruning Co.,** 4700 Montrose Ave., Chicago 41, Ill.

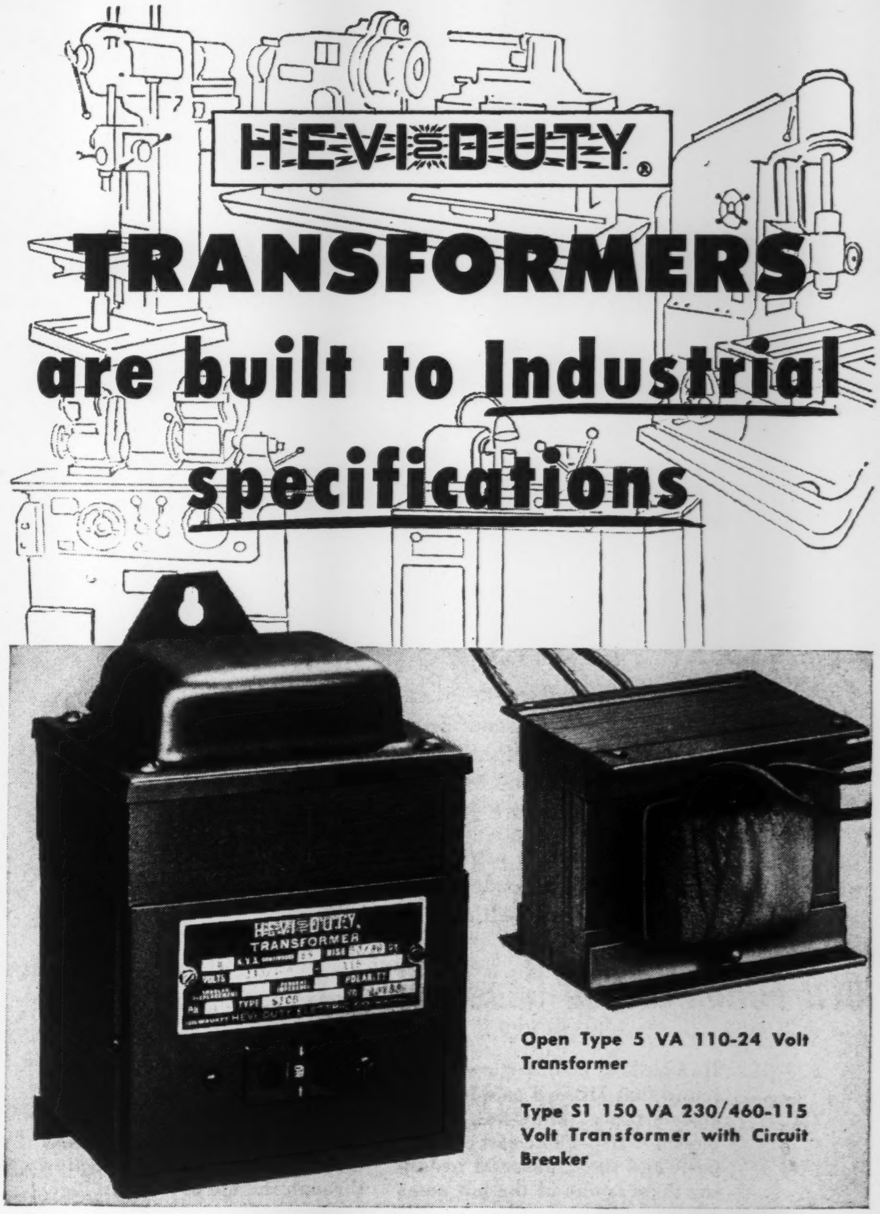


For more data circle MD-121, Page 211

Oscillogram Developer

Semi-portable oscillogram developer requires no wash process and is operable in daylight. It can process photo-sensitive paper to 12 in. wide and 250 ft long at speeds to 12 fpm. Developer consists of





HEVI DUTY

TRANSFORMERS are built to Industrial specifications

Open Type 5 VA 110-24 Volt Transformer

Type S1 150 VA 230/460-115 Volt Transformer with Circuit Breaker

You can now buy small specialty transformers for industrial control built to the same high standards that have chacterized larger HEVI DUTY transformers for many years. They are . . .

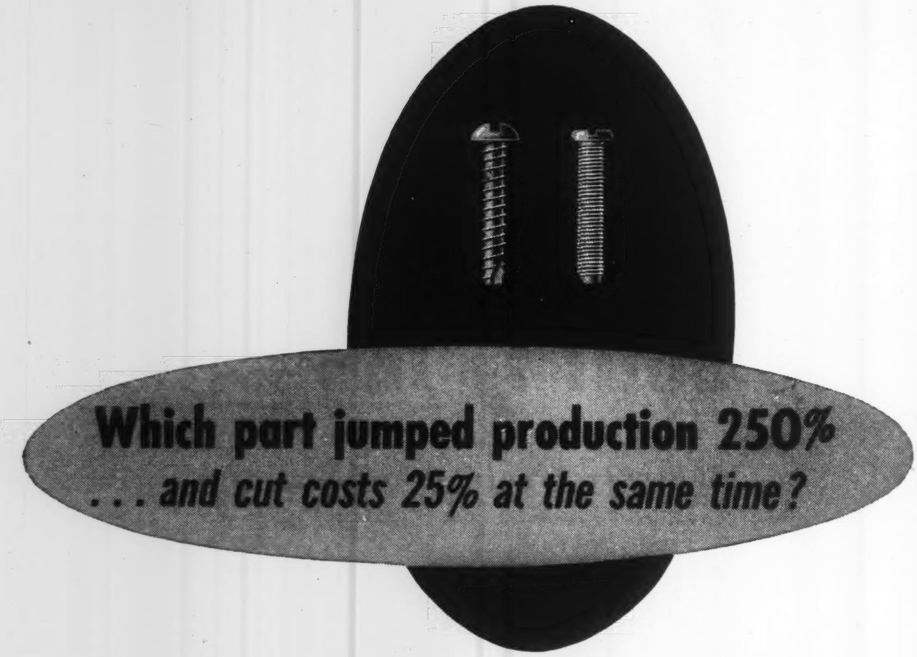
★ Designed for HEVI DUTY service.

★ Vacuum pressure impregnated with moisture and corrosion resistant varnish for HEVI DUTY use.

★ Completely tested for HEVI DUTY applications.

Sizes 5 VA and larger are available
Write for complete details

HEVI DUTY ELECTRIC COMPANY
MILWAUKEE 1, WISCONSIN
Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators



Which part jumped production 250%
. . . and cut costs 25% at the same time?

The self-tapping screw at left, used in a fluorescent light fixture, cost $12 per thousand. It was replaced by the *cold-formed* Milford screw at right — which costs only $9 per thousand. More important, the Milford screw is being set automatically in less than one-third the time!

Net results? Seven assemblies are now completed in the time that used to be needed for two! And annual savings in the cost of parts run well over five figures!

COLD FORMING and Good Design turned the trick!

Hundreds of manufacturers have found that Milford cold-forming and technical know-how really pay off — BIG ! The cost of small parts and the expense of installing them is one of the few areas in which sizable savings can still be made — and there are two very sound reasons why Milford can help you make them.

First, Milford cold-formed parts cost far less because you don't pay for metal you don't get — and because they can be produced far faster. They're made from wire stock — without scrap or waste — on very high-speed equipment.

Second, Milford engineers, designers and product researchers are expert in re-designing your small parts to take full advantage of cold-forming economies and to permit faster and more efficient methods of installation. The men from Milford can also help you increase production through the use of modern high-speed power tools or special automatic rivet-setters, a field in which Milford has had broad and intensive experience over a period of many years.

Since you risk nothing, and stand to gain a great deal, why not put Milford to work for you? Let Milford show you how to reduce costs and save time through the use of cold-formed parts. Most important, call us in on the *new* products you're planning *before designs are frozen.* You'll be taking the high road that can lead to very substantial savings — in both time and money.

Write or phone nearest Milford Plant or Sales Representative!

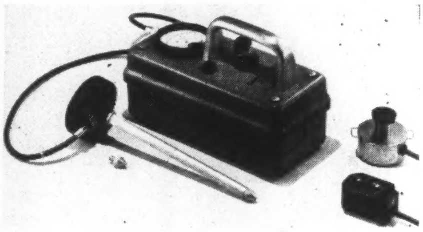
THE MILFORD RIVET & MACHINE CO.

MILFORD CONN. · NORWALK CALIF. · ELYRIA OHIO · AURORA ILLINOIS · HATBORO PENNA.

four open tanks, a surface drying unit, motor controls and paper guides. The tanks, containing developer, stop-bath and stabilizer, stand in a water jacket that is electrically heated and thermostatically controlled to 100 F. Drying is accomplished by drawing the developed oscillogram over the electrically heated cover of the unit. Powered by a 220-v, 60-cycle, 20-amp motor, the unit is 15½ in. high, 20 in. wide, 23 in. long and weighs 100 lb. Made by Meter and Instrument Dept., **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-122, Page 211

Peak-Reading Accelerometer



Portable Carometer, model 521-A, is used for reading transient peak acceleration directly in g's. The meter records the highest acceleration received by the pickup head and retains the reading for two hours or until reset to zero. Three ranges of sensitivity, 0.1-g, 1 g and 10 g (approximately 0.1-v, 1 v and 10 v) full scale, are provided. Frequency response, which is approximately flat from 7 to 70 cycles per second, can be extended. The use of appropriate transducers and modification of the input circuit permit various applications, including measurement of the peak of a transient for light, velocity, sound and line voltages. Made by **Victoreen Instrument Co.,** 3800 Perkins Ave., Cleveland 14, O.

For more data circle MD-123, Page 211

Continuous Film Graph

Printed on 0.0075-in. acetate film base, ¼-in. continuous film graph or grid sheet is accurate to 0.005-in. per running foot. It is printed in black ink, with every tenth line

A complete line of
PowerGrip
"TIMING" Belts
by U.S. Rubber

U.S. PowerGrip TIMING Belt with its positive engagement takes hold of the pulley grooves with perfect fit, perfect grip. Slippage or power loss can't happen.

FAST DELIVERY
COMPLETE ENGINEERING SERVICE
FULL STOCKS

As an industrial designer, you have often met problems involving the transmission of mechanical power: hand tools, lathes, drill presses, saws, electric typewriters are some examples. In such cases, you had to go along with the limitations imposed by V-belts, chain drives or gears. But now the U. S. PowerGrip TIMING® Belt, developed and perfected and thoroughly proved for over six years by United States Rubber Company, gives you entirely new freedom, new scope, new horizons of design. MOREOVER, the "U. S." network of distribution centers, sales offices and TIMING Belt Distributors permits fast supply plus complete engineering service.

EVER WISH YOU COULD USE SMALLER PULLEYS? You can with the U. S. PowerGrip TIMING Belt... *no slippage, no take-up.* This permits very short centers and high ratios. Light weight of PowerGrip permits high speeds.

DO LUBRICATING AND HOUSING DEVICES GET IN YOUR WAY? The absence of metal-to-metal contact in the U.S. PowerGrip TIMING Belt makes lubricants and oil-retaining housings unnecessary. Less cost, less weight.

DO HIGH BELT SPEEDS SLOW YOU DOWN? The U. S. TIMING Belt can easily handle speeds up to 16,000 F.P.M. Light weight keeps centrifugal force way down. Yet, because it cannot slip, U. S. PowerGrip TIMING Belt can be operated at speeds so slow as to be imperceptible.

WHAT ABOUT HORSEPOWER? H.P. Range is 1/100 to 300 or more. Stock drives run to 50 H.P., but wider belts and pulleys can be made on order in standard lengths and diameters.

IS EFFICIENCY ALL IT COULD BE? Because there are no friction-creating joints, no slippage loss, no lubricated drag—minimum heat generation and minimum bearing loads, U. S. PowerGrip TIMING Belts have an efficiency of close to 100%.

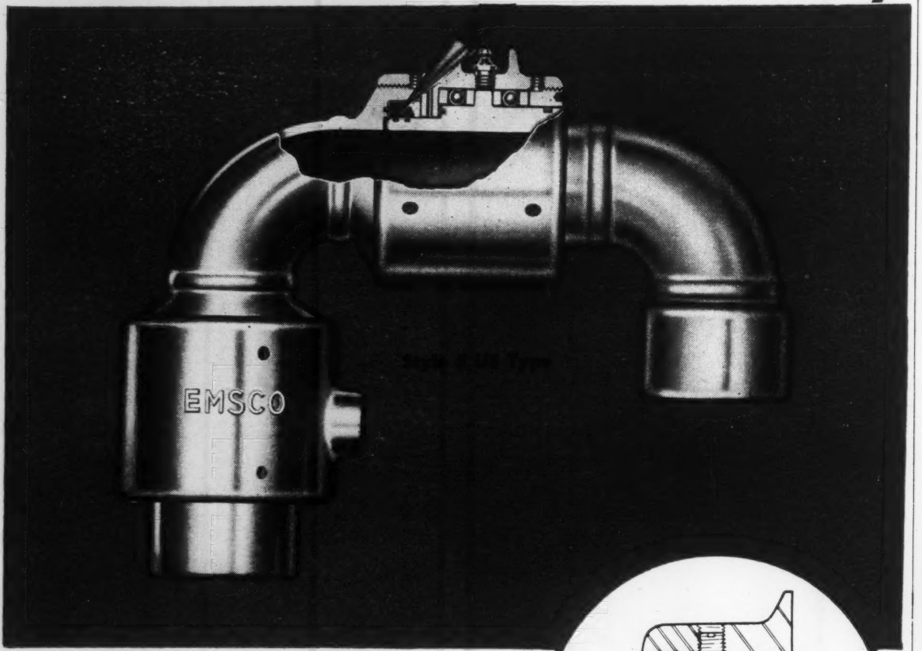
Write to any of the 26 District Sales Offices or the address below. Ask for free catalog.

"U. S." Research perfects it ... "U. S." Production builds it ... U. S. Industry depends on it

UNITED STATES RUBBER COMPANY
MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

EMSCO SWIVEL FITTINGS LAST LONGER — here's why



GROOVED PACKING
Type US for high temperature or Corrosive Service.

UNIQUE DESIGN PERMITS EASY MAINTENANCE WHILE IN OPERATION

Three basic advantages of the Emsco Ball Bearing Swivel Fitting are:

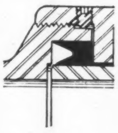
1. FREE TURNING
2. EFFICIENT PACK-OFF
3. LONG LASTING

An Emsco Swivel Fitting is practically unexpendable for the reason that, after long service, both the packing and the ball races are easily adjustable and replaceable. This means no discarded fittings—no costly return to the factory for repairs.

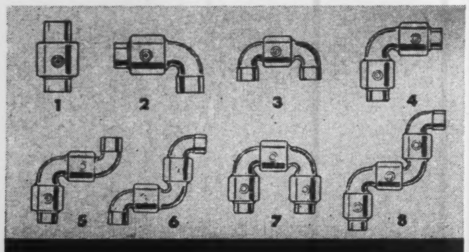
Emsco "free turning" Ball Bearing Swivel Fittings are manufactured for almost every type of service, from high vacuum to pressures of 15,000 psi., and from sub-zero temperatures to 750°F. Complete information, prices and delivery upon request.

Deformable packing extruded into annular grooves assures a positive seal. This Emsco patented method does not affect ease of turning. Any packing material such as asbestos, Blue African Asbestos or Teflon may be used in the US Type fitting.

Fittings using a lip type packing are available as Type HS or HP, depending on pressure involved



LIP TYPE PACKING



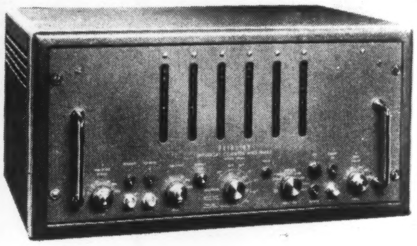
8 BASIC STYLES—OVER 500 MODELS

EMSCO
MANUFACTURING COMPANY
BOX 2098, TERMINAL ANNEX
Houston, Texas • LOS ANGELES 54, CALIF. • Garland, Texas

broken for easy identification. Sheets can be supplied in both clear and matte finish, cut to stock sizes, as well as in rolls up to 50 ft long. Sheet width is 36 in., with working surface of 35 in. Used as a base planning graph for plotting or layout of large-scale templates, the grid sheet can be written on with pen, pencil or crayon. Made by **Repro-Templets Inc.**, Pennsylvania Ave., Oakmont, Pa.

For more data circle MD-124, Page 211

Counter and Timer



Model 5510 direct-reading universal counter and timer measures and indicates time intervals from 3 microseconds to 1 million seconds with a maximum accuracy of ±1 microsecond. It measures and indicates frequencies from 0 to 1 megacycle with a maximum accuracy of ±1 cycle and measures the period of frequencies from 0 cycles per second up with an accuracy of ±1 microsecond. The instrument can also be operated as a straightforward electronic counter at rates up to 1 million cycles per second. Mounted on a standard 8¾ x 19-in. relay rack panel, it includes dc coupled channels, performs scanning to any multiple of 1 or 10 seconds, and has a direct test of all time-base frequencies. Automatic operation is with display from 0.2 to 5 seconds; manual operation, with infinite display. Made by Berkeley Div., **Beckman Instruments Inc.**, 2200 Wright Ave., Richmond, Calif.

For more data circle MD-125, Page 211

Power Supply

Model PS 503 high-voltage power supply weighs 2 lb and measures

what's your problem?

$X + 32 - R^2 \div 126 + 7$
$+ P + 2^2 - 76 \times \pi RT - 10_2$
$\times 14\ 2 + 7 \cdot 48 \div 21 \times 34_3$
$\div 12 \times M^7 = ?$

Parts? Finishes? Components? Materials? Maybe one of the advertisements in this issue of MACHINE DESIGN has the answer to your current mental whiplash.

Or maybe the answer is suggested but you want to find out for sure. Why not spend a few seconds right now and get it over with?

Fill out one of the advertising inquiry cards (always *yellow*) and shoot it to us. No letters or postage necessary.

We'll send your inquiry immediately to the advertiser and he will then reply directly to you.

USE THE YELLOW CARDS ON PAGE 37

NEW at CASH ACME

PR & R Valve with "UNIVERSAL JOINT" SEATING

For Heavy, Dirty or Viscous Fluids

- Cadmium plated iron or all bronze bodies, monel or neoprene diaphragm, stainless steel renewable piston and seat.
- Standard valve equipped with square head adjusting screw. "T" handle or handwheel also available.
- All working parts easily accessible without removing valve from line.
- **For additional information on Type BBC and other new automatic valves in the Cash-Acme line, write our Engineering Department at the address below. To avoid delay, please include a brief outline of your pressure conditions and requirements.**

TYPE BBC

Pressure Reducing and Regulating Valve

- NO SMALL PORTS
- NO CLOSE FITS
- GOOD CAPACITY
- IDEAL FOR #6 "BUNKER C" OIL

Here's a direct acting, single seated, diaphragm-type pressure reducing and regulating valve that automatically reduces a high pressure to a specified lower pressure and keeps it there. Type BBC is for heavy oil service, such as on installations carrying Bunker "C" and other grades, as well as for service on installations where dirty liquids or fluids with a high viscosity are employed. Maximum initial pressure *in iron*, 200 psi; maximum reduced pressure *in iron*, 125 psi. Maximum initial pressure *in bronze*, 250 psi; maximum reduced *in bronze*, 200 psi.

CASH ACME

A. W. CASH VALVE MANUFACTURING CORP.

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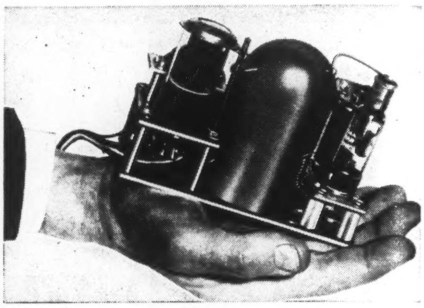

$4 \times 2\frac{5}{8} \times 5\frac{1}{2}$ in. Input of 275 v dc provides 5000 v dc at 300 microamperes. Lower voltage at higher current can be obtained. The transformer is hermetically sealed in an epoxy resin casting and operates on 30 kilocycles. Made by **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, N. Y.

For more data circle MD-126, Page 211

Temperature Indicators

Direct reading accuracy on all models of Climate-Survey temperature indicators is ± 0.5 F through all ranges. Instrument is made in three models: 196, with six overlapping ranges from -70 to 60 F; model 197, with six ranges from 10 to 140 F; and model 198, with a single range from 60 to 90 F. All are battery operated and will operate continuously for 500 hr. Each instrument has provision for reference-temperature or wet or dry-bulb readings. Use can be with various sensing element arrangements. Portable units measure $4\frac{1}{2}$ x 8 x 11 in. and weigh about 5 lb. Made by **Beckman & Whitley Inc.,** 921 E. San Carlos Ave., San Carlos, Calif.

For more data circle MD-127, Page 211

THE ENGINEER'S Library

Recent Books

Anti-Friction Bearings. *By Hudson T. Morton, president, Morton Bearing Co.; 401 pages, 8½ by 11 inches, wirebound, paper covered; published by and available from Hudson T. Morton, 815 Wildt St., P.O. Box 355, Ann Arbor, Mich., $7.75 per copy.*

Following an introductory chapter covering the historical development of antifriction bearings, a thorough discussion is made of all types of bearings, their load characteristics and their applications. Included in this book are tables of standardized bearing sizes, their numbers, tolerances, methods of measurement, housing and shaft sizes, and dimensions for mating parts such as shoulders, locknuts, lockwashers and taper sleeves. Data is given whereby a designer can compute the loads applied to antifriction bearings, compare these with bearing capacities and select the appropriate type and size of bearing for the specific application.

◆

Elementary Fluid Mechanics. *By John K. Vennard, professor of fluid mechanics, Stanford University; 413 pages, 5¼ by 8¼ inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$5.50 postpaid.*

A third edition, this book presents a fundamental treatment of fluids under static and dynamic conditions. Written with the assumption that the reader has a background of calculus, statics and dynamics, the first half of this volume is devoted to a discussion of principles of one - dimensional flow, compressible and incompressible ideal fluid flow, flow of a real fluid and impulse-momentum. Fluid flow in pipes and open channels, and about immersed objects, along with methods and means of measuring fluids, are discussed in the

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remainder of the text. Also included are numerous illustrations, a total of 873 problems, and extensive references throughout.

◆

Business, Legal, and Ethical Phases of Engineering. *By D. T. Canfield and J. H. Bowman, professors of electrical engineering, Purdue University; 377 pages, 5¾ by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, $6.00 *postpaid.*

Intended to be primarily a textbook, this second edition briefly covers the business, legal, and ethical phases of all fields of engineering. Engineering business economics are discussed in Part 1 in terms of such items as stocks, bonds, notes, interest, annuities, insurance, depreciation, maintenance, and replacement. Methods for determining costs comprise material in the second section, while business law and its importance to engineers make up Part 3. The last part of the book covers engineering bids and specifications, patents, copyrights, trade-marks, industrial hazards, etc.

◆

Theory and Design of Steam and Gas Turbines. *By John F. Lee, associate professor of mechanical engineering, North Carolina State College; 516 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, $9.00 *postpaid.*

Modern theory of steam and gas turbines and turbine flow-passage design are presented in this textbook in such a manner that a background in aerodynamics or gas dynamics is not essential for a full understanding of the material. The first six chapters deal with steam and gas turbine types and cycles, and fundamentals of thermodynamics and gas dynamics. Chapters 7, 8, 9, and 10 cover energy interchanges in fluid machinery and design aspects of turbine nozzles, flow passages, rotors, casings, accessories, parasitic losses,

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and metallurgical considerations. The remainder of the book is devoted to steam-turbine control and performance, centrifugal and axial-flow compressors, combustion, regenerators, and gas-turbine power plants.

◆

Electricity and Magnetism. *By Edson Ruther Peck, associate professor of physics, Northwestern University; 488 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, $7.50 *postpaid.*

Requiring a background in physics and calculus, this advanced textbook provides a critical discussion of the underlying principles of electromagnetism including field and circuit theory. A detailed analysis is made in such areas as electrostatics, dielectric theory, electric current, dc and ac circuits, steady-state magnetism, electromagnetic induction, transient currents, and electromagnetic waves.

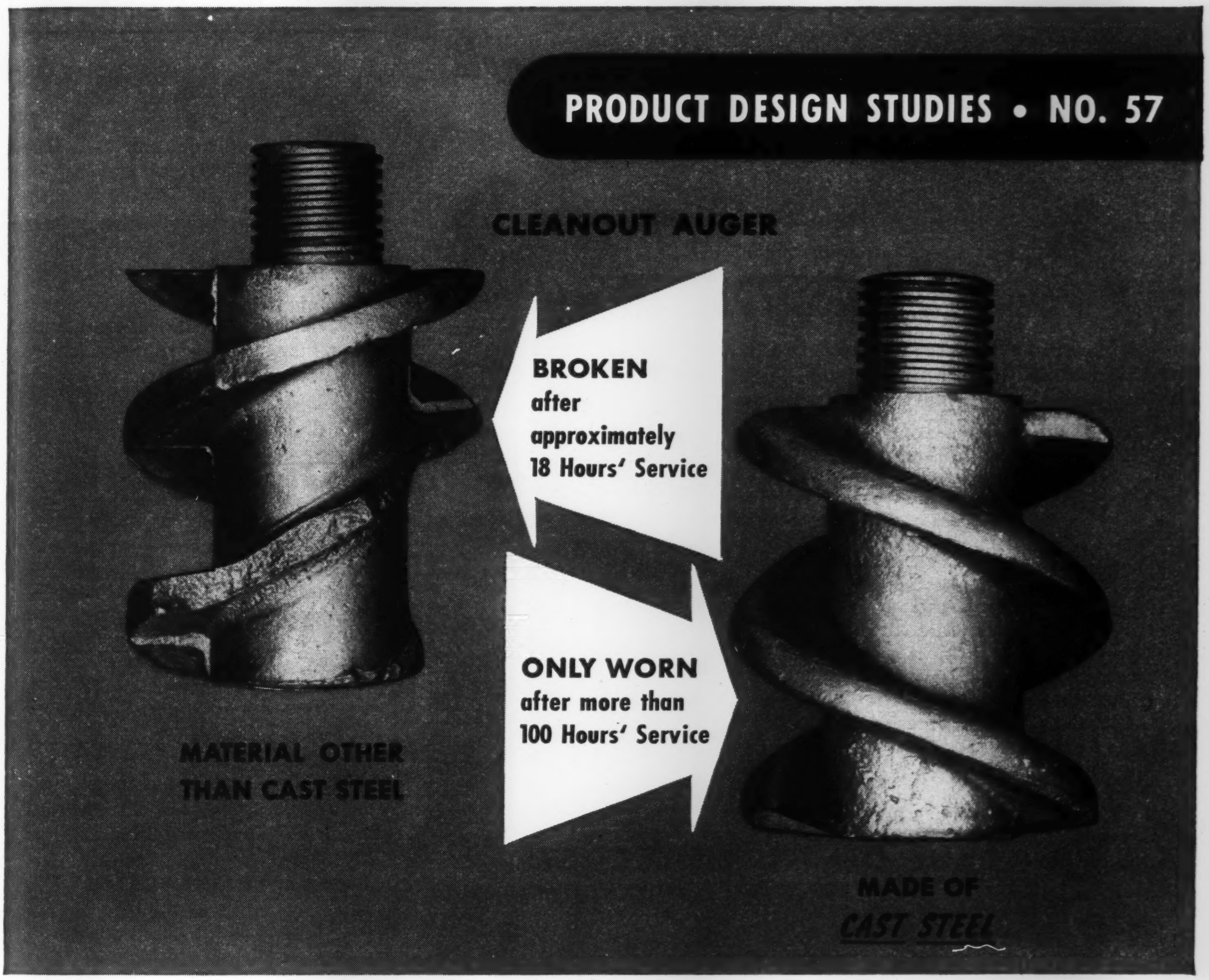
◆

The Closed Die Forging Process. *By P. E. Kyle, professor of metallurgy, Cornell University; 153 pages, 5½ by 8¼ inches, clothbound; published by the MacMillan Co., New York; available from* MACHINE DESIGN, $1.50 *postpaid.*

Essential steps of producing drop forgings are described in this book along with a discussion for uses to which closed-die drop forgings can be adapted. Much of Chapter 8 is devoted to forging tolerances, while the selection of steels and nonferrous metals and alloys employed for forgings is covered by means of both text material and extensive tables of properties in Chapter 9. A 14-page glossary of forging terms follows the last chapter in the book.

◆

Direct-Current Circuits. *By Earle M. Morecock, electrical dept. head, Rochester Institute of Technology; 398 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co.*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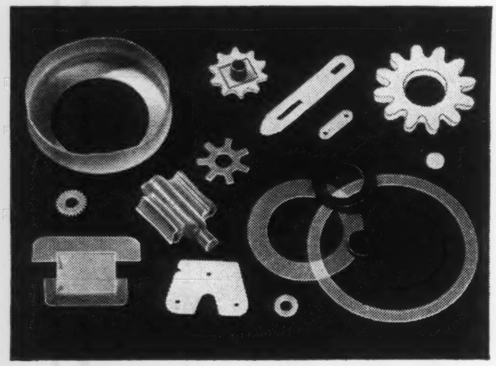

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Inc.; available from MACHINE DESIGN, *$5.00 postpaid.*

A second edition, this is a basic text on dc electrical theory. The book deals with electrical units, magnetism and electromagnetism, electrical measurement, conductors and insulation, batteries, network circuits, and magnetic circuits. Nearly every chapter is concluded with numerous pertinent questions and problems.

New Standards

Designation and Working Ranges of Grinding Machines of the Horizontal Reciprocating Table Type and of Plain Cylindrical Grinding Machines. *ASA B*5.32, *B*5.33-1953; 7 *pages, 8½ by* 11 *inches, paperbound; available from American Society of Mechanical Engineers,* 29 *W. 39th St., New York* 18, *N. Y.,* $1.00 *per copy.*

The first of this pair of standards covers all sizes of reciprocating table surface grinders having horizontal spindles. It establishes definition of size; wheel sleeve diameters; width and length of working surface; and longitudinal, transverse and vertical travel. In the second standard, which applies to all swings of plain cylindrical grinding machines up to and including 36 inch diameter, factors discussed are definition of size, wheel hole sizes, swing and length.

◆

Letter Symbols for Acoustics. *ASA Y*10.11-1953; 11 *pages,* 8½ *by* 11 *inches, paperbound; available from American Society of Mechanical Engineers,* 29 *W. 39th St., New York* 18, *N. Y.,* $1.00 *per copy.*

Introduced by general principles of letter symbol standardization, this standard on acoustics contains over six pages of material devoted to two alphabetical lists—one in order of quantity and the other in order of symbol.

◆

Rotating Air Cylinders and Adapters. *ASA B*5.5-1954; 6 *pages,* 8½ *by*

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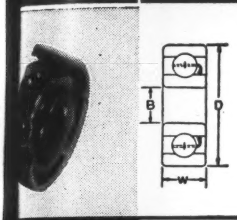
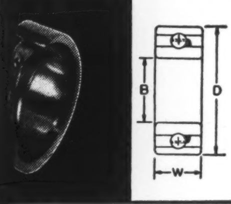


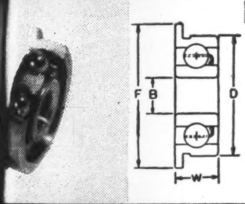
Retainer

Brg. No.	B	D	W
R0	3/64 (.0469)	5/32 (.1562)	1/16 (.0625)
R1	(.0550)	3/16 (.1875)	5/64 (.0781)
R1-4	5/64 (.0781)	1/4 (.2500)	3/32 (.0937)
R1-5	3/32 (.0937)	5/16 (.3125)	7/64 (.1094)
R2-5	1/8 (.1250)	5/16 (.3125)	7/64 (.1094)
R2	1/8 (.1250)	3/8 (.3750)	5/32 (.1562)



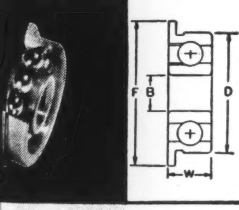
Retainer Extra Light

R133	3/32 (.0937)	3/16 (.1875)	1/16 (.0625)
R144	1/8 (.1250)	1/4 (.2500)	3/32 (.0937)
R155	5/32 (.1562)	5/16 (.3125)	7/64 (.1094)
R156	3/16 (.1875)	5/16 (.3125)	7/64 (.1094)
R166	3/16 (.1875)	3/8 (.3750)	1/8 (.1250)
R168	1/4 (.2500)	3/8 (.3750)	1/8 (.1250)
R188	1/4 (.2500)	1/2 (.5000)	1/8 (.1250)
R613M	6mm.	13mm.	3.5mm.



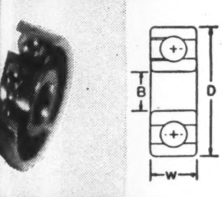
Flanged Retainer

FR1	(.0550)	3/16 (.1875)	5/64 (.0781)
FR1-4	5/64 (.0781)	1/4 (.2500)	3/32 (.0937)
FR1-5	3/32 (.0937)	5/16 (.3125)	7/64 (.1094)
FR2-5	1/8 (.1250)	5/16 (.3125)	7/64 (.1094)
FR144	1/8 (.1250)	1/4 (.2500)	3/32 (.0937)
FR155	5/32 (.1562)	5/16 (.3125)	7/64 (.1094)
FR156	3/16 (.1875)	5/16 (.3125)	7/64 (.1094)
FR166	3/16 (.1875)	3/8 (.3750)	1/8 (.1250)
FR188	1/4 (.2500)	1/2 (.5000)	1/8 (.1250)



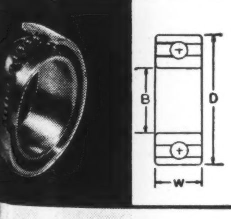
Flanged Full

F13	(.0550)	3/16 (.1875)	5/64 (.0781)
F14	5/64 (.0781)	1/4 (.2500)	3/32 (.0937)
F15	3/32 (.0937)	5/16 (.3125)	7/64 (.1094)
F154	1/8 (.1250)	5/16 (.3125)	7/64 (.1094)
F155	5/32 (.1562)	5/16 (.3125)	7/64 (.1094)
F156	3/16 (.1875)	5/16 (.3125)	7/64 (.1094)



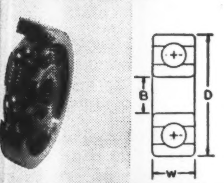
Full

10	(.0250)	(.1000)	1/32 (.0312)
12	(.0400)	1/8 (.1250)	3/64 (.0469)
12½	3/64 (.0469)	5/32 (.1562)	1/16 (.0625)
13	(.0550)	3/16 (.1875)	5/64 (.0781)
14	5/64 (.0781)	1/4 (.2500)	3/32 (.0937)
15	3/32 (.0937)	5/16 (.3125)	7/64 (.1094)
16	1/8 (.1250)	3/8 (.3750)	5/32 (.1562)



Full Extra Light

144	1/8 (.1250)	1/4 (.2500)	3/32 (.0937)
154	1/8 (.1250)	5/16 (.3125)	7/64 (.1094)
155	5/32 (.1562)	5/16 (.3125)	7/64 (.1094)
156	3/16 (.1875)	5/16 (.3125)	7/64 (.1094)
157	7/32 (.2187)	5/16 (.3125)	7/64 (.1094)
168	1/4 (.2500)	3/8 (.3750)	1/8 (.1250)
1810	5/16 (.3125)	1/2 (.5000)	5/32 (.1563)



Spring Separator

R1-4Z	5/64 (.0781)	1/4 (.2500)	3/32 (.0937)
R1-5Z	3/32 (.0937)	5/16 (.3125)	7/64 (.1094)
R2-5Z	1/8 (.1250)	5/16 (.3125)	7/64 (.1094)
R2Z	1/8 (.1250)	3/8 (.3750)	5/32 (.1562)
R155Z	5/32 (.1562)	5/16 (.3125)	7/64 (.1094)
R168Z	1/4 (.2500)	3/8 (.3750)	1/8 (.1250)

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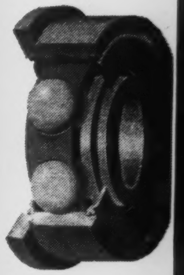
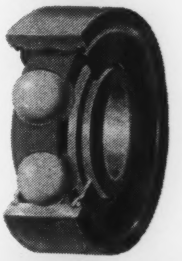


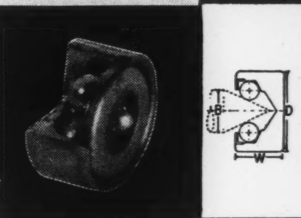
Brg. No.	B	D	W
FR1-P,PP	(.0550)	3/16 (.1875)	(.1094)
FR1-4P,PP	5/64 (.0781)	1/4 (.2500)	(.1406)
FR1-5P,PP	3/32 (.0937)	5/16 (.3125)	(.1406)
FR2-5P,PP	1/8 (.1250)	5/16 (.3125)	(.1406)
FR2-P,PP	1/8 (.1250)	3/8 (.3750)	(.1562)
FR144P,PP	1/8 (.1250)	1/4 (.2500)	(.1094)
FR155P,PP	5/32 (.1562)	5/16 (.3125)	(.1250)
FR156P,PP	3/16 (.1875)	5/16 (.3125)	(.1250)
FR166P,PP	3/16 (.1875)	3/8 (.3750)	(.1562)
FR168P,PP	1/4 (.2500)	3/8 (.3750)	(.1250)
FR188P,PP	1/4 (.2500)	1/2 (.5000)	(.1875)



Shielded Radial

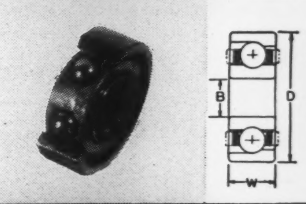
R0P,PP	3/64 (.0469)	5/32 (.1562)	(.0937)
R1P,PP	(.0550)	3/16 (.1875)	(.1094)
R1-4P,PP	5/64 (.0781)	1/4 (.2500)	(.1406)
R1-5P,PP	3/32 (.0937)	5/16 (.3125)	(.1406)
R2-5P,PP	1/8 (.1250)	5/16 (.3125)	(.1406)
R2P,PP	1/8 (.1250)	3/8 (.3750)	(.1562)
R144P,PP	1/8 (.1250)	1/4 (.2500)	(.1094)
R155P,PP	5/32 (.1562)	5/16 (.3125)	(.1250)
R156P,PP	3/16 (.1875)	5/16 (.3125)	(.1250)
R166P,PP	3/16 (.1875)	3/8 (.3750)	(.1562)
R168P,PP	1/4 (.2500)	3/8 (.3750)	(.1250)
R188P,PP	1/4 (.2500)	1/2 (.5000)	(.1875)

OTHER TYPES



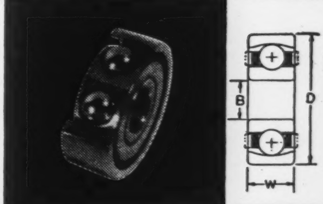
Pivot

Brg. No.	B	D	W
22½M	(.040)	4mm.	2.4m
23M	(.050)	5mm.	3.2m
24	(.085)	1/4 (.2500)	1/8 (.125
24H	(.085)	1/4 (.2500)	1/8 (.125
26	(.165)	3/8 (.3750)	3/16 (.187
26H	(.165)	3/8 (.3750)	3/16 (.187



Angular Contact

113	(.0550)	3/16 (.1875)	5/64 (.078
114	5/64 (.0781)	1/4 (.2500)	3/32 (.093
115	3/32 (.0937)	5/16 (.3125)	7/64 (.109
1154	1/8 (.1250)	5/16 (.3125)	7/64 (.109
116	1/8 (.1250)	3/8 (.3750)	5/32 (.156



Self Aligning

214	5/64 (.0781)	1/4 (.2500)	3/32 (.093
215	3/32 (.0937)	5/16 (.3125)	7/64 (.109
2154	1/8 (.1250)	5/16 (.3125)	7/64 (.109
216	1/8 (.1250)	3/8 (.3750)	5/32 (.156

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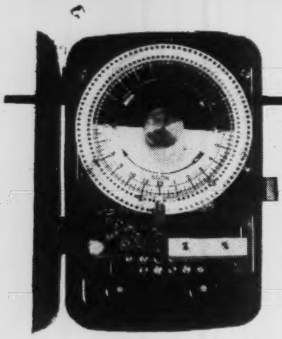

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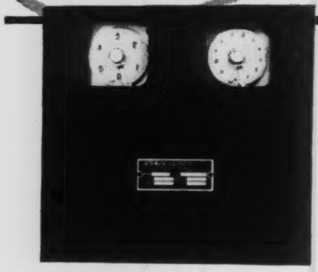

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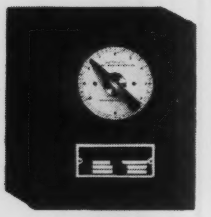

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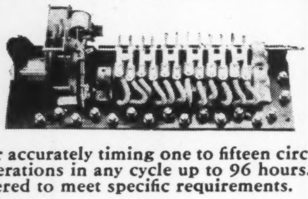

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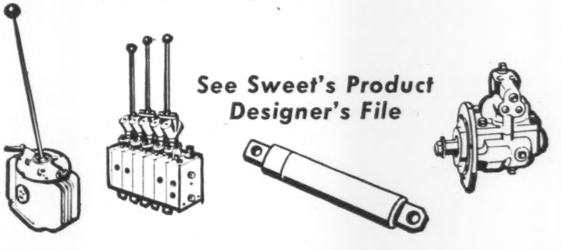

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DESIGN
ABSTRACTS

Residual Stresses

. . . their influence on metal properties

By R. L. Mattson
Research Laboratories Div.
General Motors Corp.
Detroit, Mich.

DESIGN importance of the effect of residual stresses on the fatigue life of metals has grown in significance as machine loads and speeds increase. These hidden stresses must be considered at least as important as stresses caused by externally applied loads. Perhaps they are even more important because the distribution of stresses in a part caused by external loads is relatively simple to predict as compared with the triaxial internal force distribution caused by the combined mechanical and thermal history of a part. Chemical composition, shape, size, heat treatment and production operations all leave their mark in the formation of the final residual stress pattern throughout a piece of metal. Forces are trapped in many component parts of machines and only become manifest when such parts crack on the shelf or fail prematurely in service.

Applied Loads: The relationship between load stresses and residual stresses for a simple beam are shown by the stress diagram in *Fig.* 1. The dashed line shows the typical stress distribution in simple bending. The shaded area shows an actual residual stress distribution found in a leaf spring specimen. This stress distribution existed in the piece of steel with no external forces applied and when added to the load stress distribution, produced the condition shown by the solid line in *Fig.* 1. The material suffers lower stress near the critical top surface because of the protective residual compressive stress component at or near the surface.

Fatigue Life: Results of fatigue tests and residual stress analyses of flat specimens of rectangular cross section are shown in *Fig.* 2. These specimens were fatigue tested in one-directional bending and were cycled from approximately zero to 200,000 psi tensile stress. Nonpeened specimens had the shortest fatigue life and the lowest residual compressive stress near the surface. The shot-peened group had longer life and also had a higher residual compressive stress. The group which had the longest life was shot peened while under strain (sometimes called "strain peening") and had the highest residual compressive stress. The relationship between residual stresses and fatigue properties is apparent.

A plot of data in *Fig.* 2 combined with some supplementary data provide a "net stress" versus fatigue life comparison, *Fig.* 3.

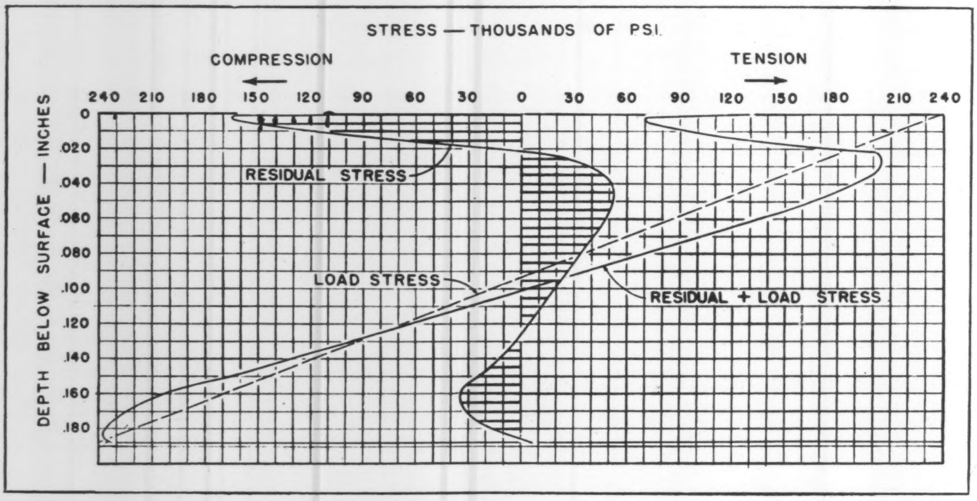


Fig. 1 — Curves showing relationship of bending residual stresses in a leaf spring specimen

Net stress is defined as the algebraic sum of load stress and residual stress as shown by the upper right insert. The load stress at the surface for all of these specimens was held constant at 200,000 psi. Hence, the net stress was obtained by simply adding algebraically the peak residual compressive stress to the load stress at the corresponding depth. Nonpeened specimens which had little compressive stress had high net stress and a correspondingly low fatigue life. Shot-peened specimens had a medium value of residual compressive stress, a medium net stress and a corresponding medium fatigue life. Although those specimens which were peened while under strain had a high residual compressive stress, they also had low net stress and a high fatigue life. Thus, net stress can be considered to be the maximum stress that the material is subjected to in a tensile direction and hence is related to the fatigue life. Experimental evidence shows that residual stresses do affect fatigue properties of metals and behave in a manner

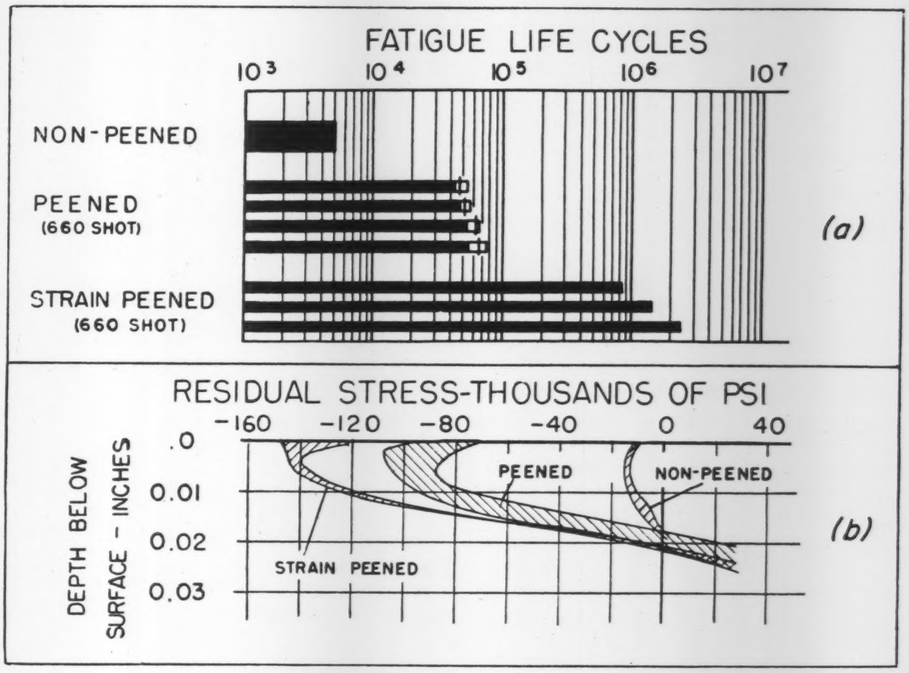


Fig. 2—Right—Fatigue life comparison for nonpeened, peened, and strain-peened flat metal specimens subjected to one direction bending, *a,* and residual stress distribution below the surface of specimens, *b*

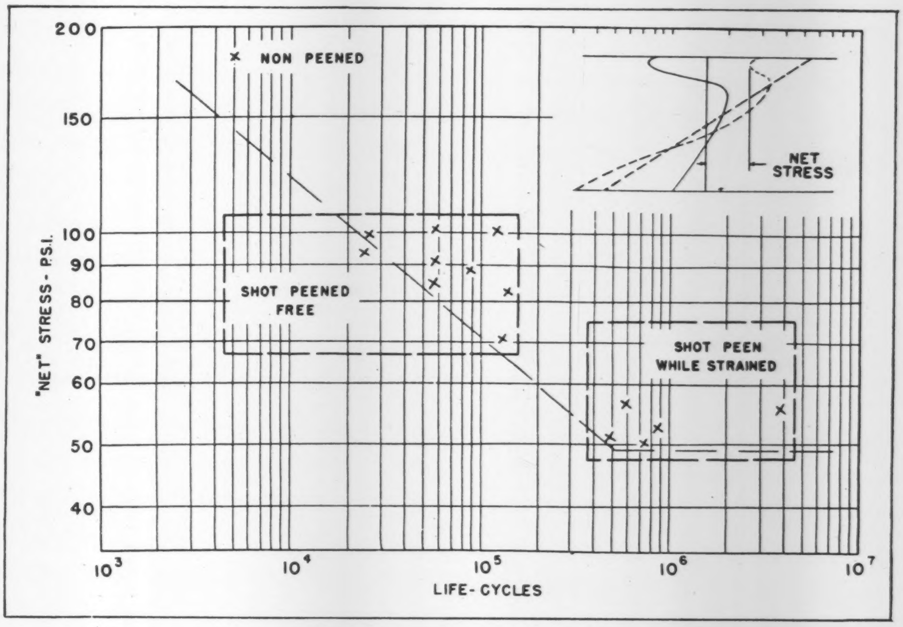


Fig. 3—Right—Plot of "net" stress (load plus residual stress) versus fatigue life for specimens in *Fig.* 2

Fig. 4—Typical residual stress curve for a bearing ball with spalling type failure

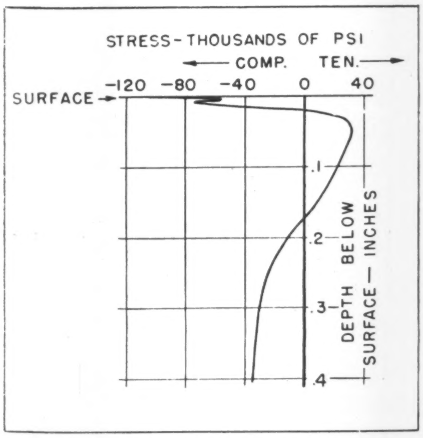


Fig. 5—Residual stress pattern causing spalling type failure in a large bearing race

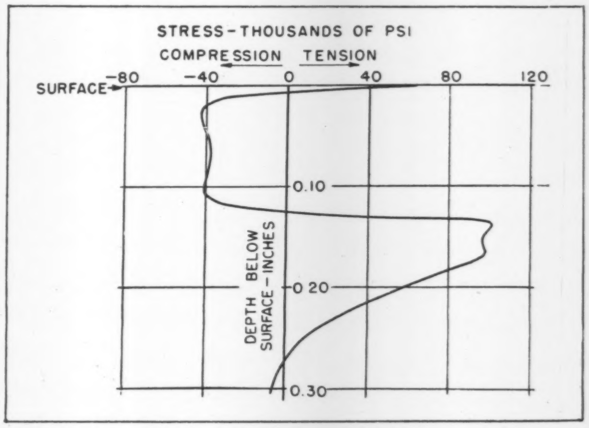
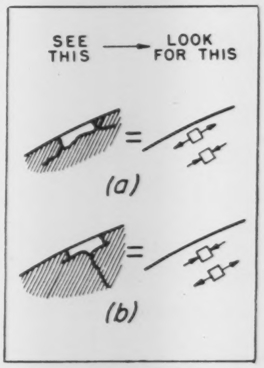


Fig. 6 — Two basic types of spalling failure, and their corresponding stress conditions



similar to applied load to stresses.

Spalling: The surface fatigue phenomenon called spalling is characterized by a flaking of a surface layer such as is sometimes encountered in gear contact surfaces. It might be considered as a special form of pitting. If the spalling type failure occurs, it is associated with a particular kind of residual stress distribution. An analysis of a failed bearing ball is shown in *Fig.* 4. The failure apparently started in a region stressed in tension below the surface and propagated radially until it encountered a zone which was residually stressed in compression. Then the fracture veered off, running parallel to the surface, and subsequently broke through to the surface. The fracture path ran parallel to the surface and was located in an area of high stress gradient. In this zone, the residual stress ranges from a fairly high compressive stress to a tensile stress in a short distance. The fracture found it difficult to penetrate a layer of metal residually stressed in compression but apparently the steep stress gradient plus the stresses imposed by contact with the race were sufficient to encourage propagation in a direction parallel to the surface.

In another typical example, the surface of an induction-hardened bearing race was found to be full of cracks. These cracks extended vertically from the surface for a short distance, then veered off and ran parallel to the surface. Results of a residual stress analysis of an adjacent area is shown in *Fig.* 5. Here again spalling was associated with a severe stress gradient. There was a tensile residual stress at the surface and a compressive stress beneath it. Actually, since the surface had cracked, much higher residual tensile stresses would be expected than those measured. The fracture penetrated vertically until it encountered a layer of material residually stressed in compression and then travelled parallel to the surface. Again, the fracture ran parallel to the surface and was also in a zone of steep stress gradient. In this case the surface tensile stress was caused by a grinding operation.

Thus, surface failures characterized by fracture planes parallel to the surface may be caused by a high residual stress gradient in that area as shown in *Fig.* 5. If there are vertical fracture planes in a surface layer in combination with a fracture plane parallel to the surface, a steep stress gradient probably exists with the surface layer in tension and the material below in compression, *Fig.* 6*a*. If there are subsurface fracture planes parallel to the surface with vertical fractures below, it would be expected that the surface layer is stressed in compression and tensile stresses prevail below, *Fig.* 6*b*.

Processing Operations: Any process which causes localized plastic flow or phase transformation of the material will set up or alter residual stresses. This, of course, means residual stresses develop or are altered by various steps in heat treatment or by machining, grinding, cold working, straightening and static and fatigue loads. With such an array of influencing factors, the complexity of the problem of predicting residual stresses in fabricated parts is apparent. Some of the effects of these operations are listed in *Fig.* 7 together with a

RESIDUAL STRESS INTRODUCED OR ALTERED BY	TEMPERATURE DIFFERENCE	PHASE TRANSFORMATION	COLD PLASTIC FLOW	WARPAGE	ALTERED CHEMISTRY
HEAT TREATMENT (QUENCHING AND TEMPERING)	YES	YES	NO	NO	NO
CASE HARDENING (CARBURIZING AND NITRIDING)	YES	YES	NO	NO	YES
INDUCTION HARDENING	YES	YES	NO	NO	NO
MACHINING	POSSIBLY	UNKNOWN	YES	YES	NO
GRINDING	YES	UNKNOWN	YES	YES	NO
COLD WORKING SHOT PEENING, SURFACE ROLLING, TUMBLING, HONING, LAPPING, BLAST CLEANING	NO	NO	YES	YES	NO
STRAIGHTENING	NO	NO	YES	NO	NO

Fig. 7—Causes of residual stresses introduced by production processes

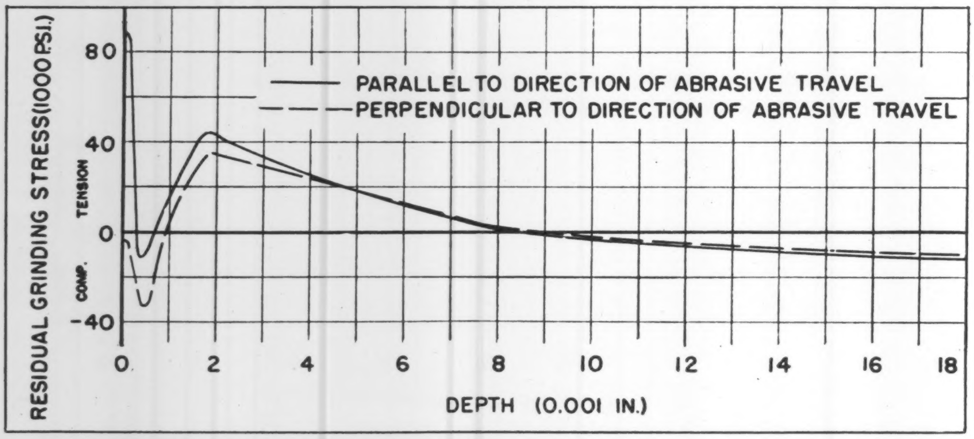


Fig. 8—Residual stress distribution in annealed manganese oil-hardening tool steel measured for one depth of cut

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VOL. 2 VICKERS INCORPORATED, DETROIT, MICHIGAN NO. 4

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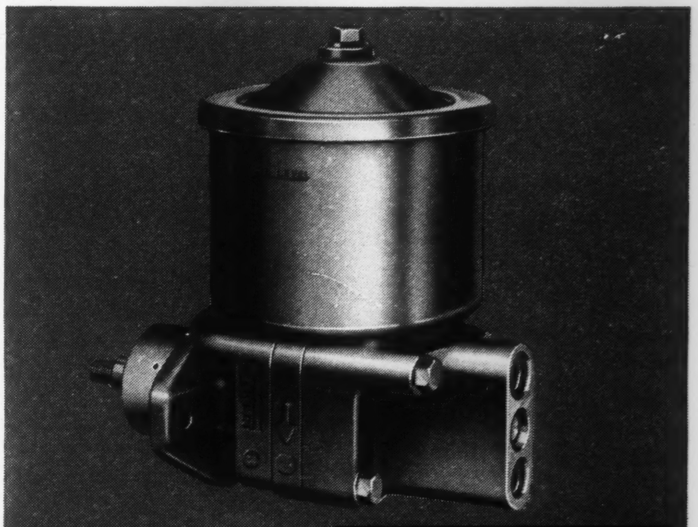

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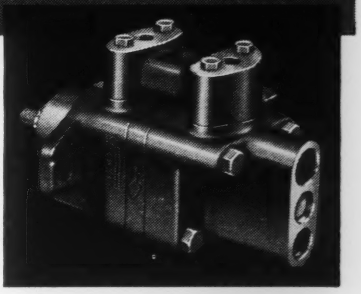

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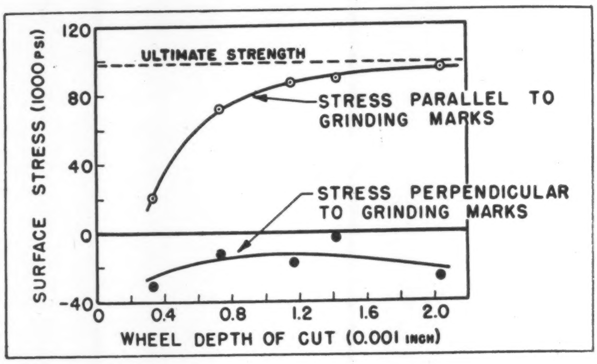


Fig. 9—Right — Surface residual stresses in annealed manganese oil - hardening tool steel measured parallel and perpendicular to grinding marks

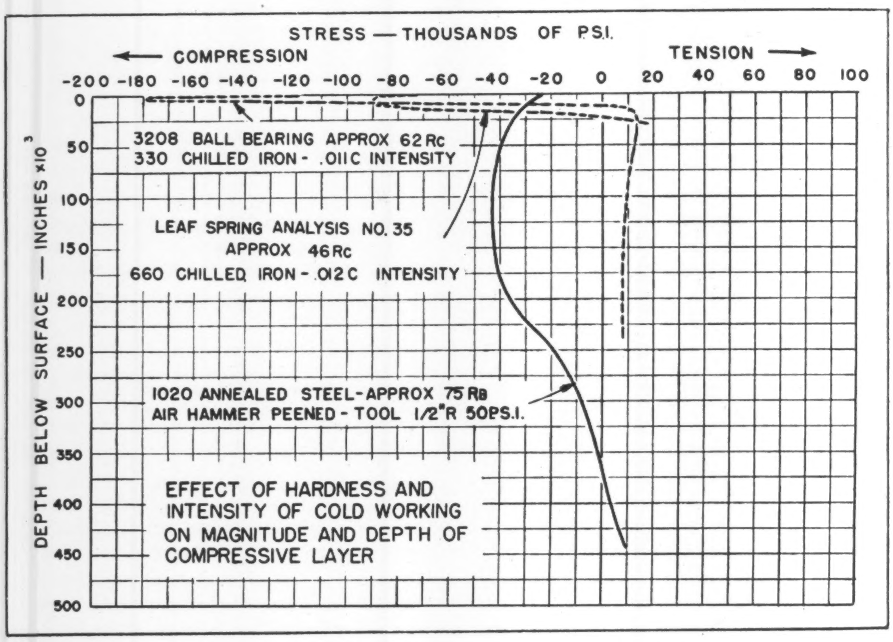


Fig. 10 — Above — Range of residual compressive stresses introduced by surface shot-peening of three ferrous materials

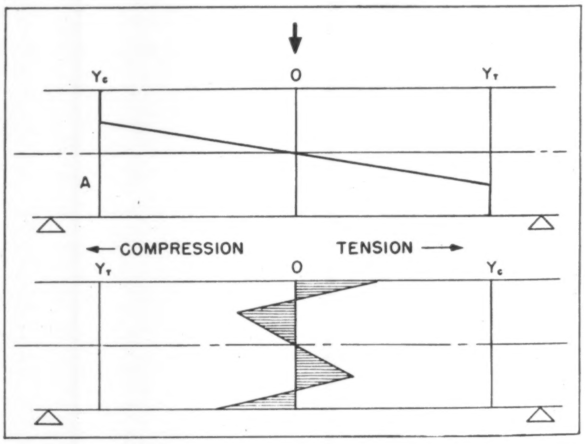


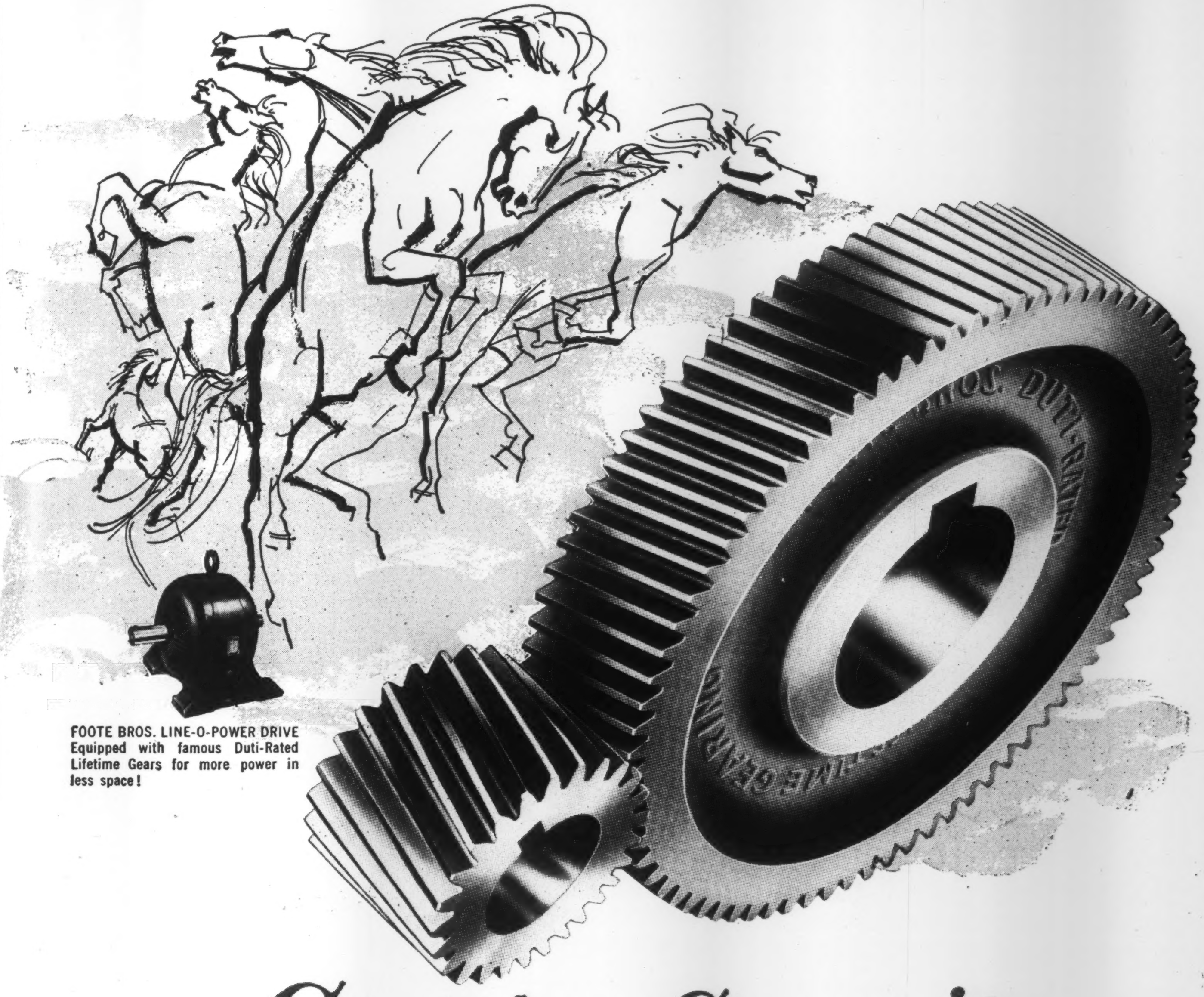
Fig. 11—Right—Plot of induced residual stresses in a beam cold straightened in one direction only

classification of the mechanism responsible for the residual stresses.

Heat Treatment: Residual stresses introduced or altered by heat treatment are generally divided into two classes which can at times work in opposing directions. These are called thermal stresses and transformation stresses. Thermal stresses are caused by temperature differences between the inside and the outside of a component. Residual stresses result if at any point the stress caused by temperature difference exceeds the yield point at that temperature and causes localized plastic flow. If thermal stresses alone were operating, the quenching operation would introduce in the surface of a part a state of residual compression. The transformation stresses are caused by phase transformation and are brought about because changes from one phase to another often entail a volume change. Martensite occupies more space than the austenite from which it comes and thus imposes stresses on neighboring areas as well as within itself. Another complication arises because transformation itself is undoubtedly affected by the transitional stress state. The combination of thermal stresses and transformation stresses produce the final stress state which can often be tensile at a critical surface, but could just as well be compressive if we knew how to produce it.

Machining: Little experimental data is available on the nature of the residual stresses introduced by machining operations. The variety of metal removal methods suggests that considerable variation is possible in the stresses trapped in the surface layers of the part. In *Fig.* 7 it can be noted that several factors are involved in the introduction of residual stresses during machining. Trapped stresses can be introduced by high mechanical stresses associated with the severing of the metal. These in turn are associated with the geometry of the cutting tool, speed of cutting, nature of cutting, etc. If sufficiently high temperatures are developed locally, thermal stresses or even transformation stresses might be introduced. Also, if the metal removed was originally stressed, some unexpected change in shape or size would occur, causing a change in the residual stress in the remainder.

Grinding: This is one of the most important fabricating processes, but it is also one of the major causes of residual stresses. Grinding cracks are simply manifestations of high tensile stresses introduced by the grinding process. The combination of stresses created by the grain of the wheel rubbing and cutting the metal, the heat generated locally and producing high temperature gradients, localized plastic flow, and the metallurgical phase changes which



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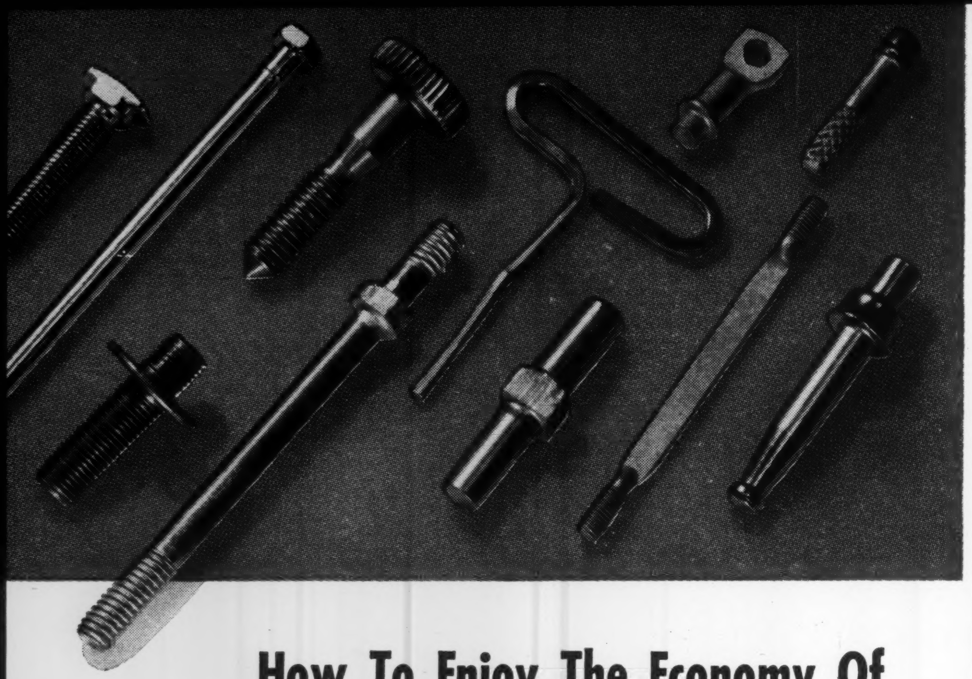

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may take place cause the resultant residual stresses. Surface temperatures as high as 3000 F due to grinding have been calculated and reported. Experimental data of Letner and Snyder of the Mellon Institute on residual stresses caused by grinding is shown in *Fig.* 8. Biaxial stresses were measured in fully-annealed manganese, oil-hardening tool steel for various depths of cut. Results of the measurements are shown for one depth of cut for both longitudinal and transverse directions of abrasive travel. In a longitudinal direction there is a layer of material stressed in tension, but in a transverse direction this surface layer is stressed in compression. So it cannot be categorically stated that grinding introduces only tensile stresses. The astonishing thing about this data is the steep stress gradient. The tensile stress at the surface is almost as high as the ultimate strength of the material and within 0.0002-inch the residual stress is compressive.

In *Fig.* 9 a plot has been made of surface residual stress versus depth of cut for both stresses in the direction of the grinding marks and perpendicular to the grinding marks. Stresses parallel to the grinding marks approach the ultimate tensile strength as cut depth increases; also, it does not take a very deep cut to introduce large tensile stresses. Stresses perpendicular to the grinding marks, at least in this case, are compressive at the surface for all depths of cut shown.

Cold Working: In cold working processes such as shot peening, surface rolling, etc., residual compressive stresses are introduced in a surface layer. Some indication of the range of residual compressive stress introduced by surface peening is shown in *Fig.* 10. Compressive stresses as high as 180,000 psi at a depth of 0.010-inch were measured in a shot-peened ball-bearing race, which of course is very hard, being over 60 Rockwell C. Compressive stresses in the order of 100,000 psi and 0.025-inch deep were introduced by shot peening leaf spring specimens of hardness 46 Rockwell C. In annealed SAE 1020 steel, residual compressive stresses of 40,000 psi and 0.35-inch deep were introduced by air hammering with a spherical-nosed tool. In these cold working processes, there is apparently a relationship between the maximum residual compressive stress introduced and the yield strength of the material. This would likely be influenced by the work-hardening tendency of the material.

Some experiments were conducted to determine the residual stresses introduced by tumbling with Alundum abrasive, which is certainly a mild form of cold working. Residual compressive stresses in the order of 70,000 psi were introduced in the surface layer and these extended to a depth of 0.002-inch. Tumbling time also affects the amount of compressive stress introduced.

Contrasting this with grinding, where tensile stresses are introduced, suggests that some form of cold working process is desirable as a final operation for parts subjected to fatigue loading.

Straightening: Since in the operation of straightening certain portions of a cross-section suffer plastic flow while other portions are strained elastically, residual stresses are introduced. If bending goes beyond the yield point as in *Fig.* 11, material near the surface yields. Upon removal of the load, the bar returns to an equilibrium position and the surface that was loaded in tension is now residually stressed in compression, while the surface that was loaded in compression is now residually stressed in tension. From fatigue tests on certain straightened axle shafts, it has been observed that failure always occurred on the side which was residually stressed in tension by bend straightening. Straightening by selective processes of surface hammering or surface rolling, in which residual compressive stresses are introduced, provides shafts of improved fatigue durability. This type of straightening introduces favorable compressive

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stresses in both surfaces.

From a paper entitled "Effects of Residual Stress on Fatigue Life of Metals" presented at the SAE Annual Meeting in Detroit, Mich., January, 1954.

Applying Transistors in Design

By J. S. Schaffner
Electronics Park
General Electric Co.
Syracuse, N. Y.

THE TRANSISTOR is slowly changing from a miraculous cure-all into a reliable component with known properties. Application techniques are becoming more well-known as engineers factor transistors into their design thinking. To get some conception of the application problems, an overall view of the different types of transistors is required.

Transistor Types and Design: The term transistor as used today refers to semiconductor devices capable of power gain. This excludes germanium diodes because such devices pass current in one direction only and are not capable of amplification.

The basic elements of semiconductor devices, including diodes and transistors, *Fig.* 1, are "barriers" which can be formed in a

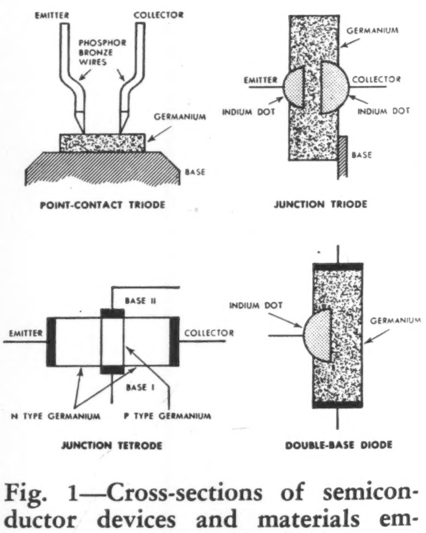

Fig. 1—Cross-sections of semiconductor devices and materials employed in their design

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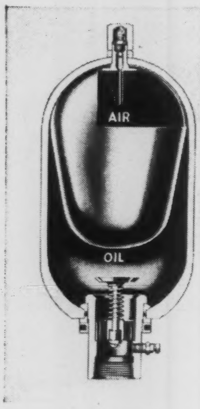

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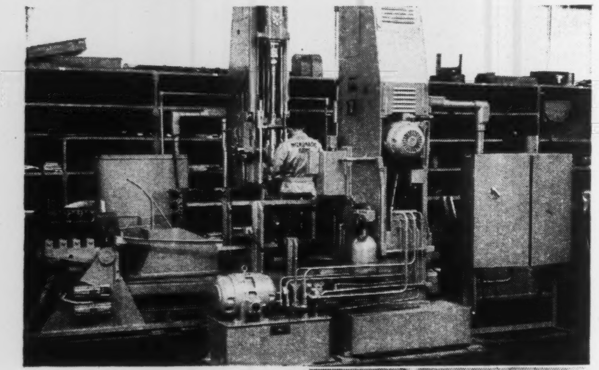

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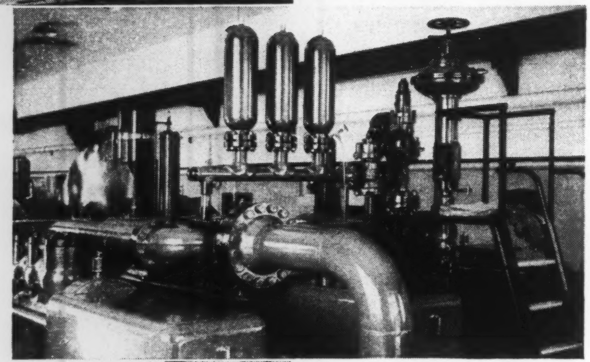

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number of ways. One way is to place a phosphor-bronze wire on a small block of germanium and weld the two together (point contact), or another way is to place a dot of indium on germanium and heat the indium so that it forms an alloy with some of the germanium (alloy junction).

The "classical" transistors were composed of two barriers, closely spaced together. However, a new class of transistors using only one barrier was developed recently. The most promising of these is the double-base diode, a switching device that is the semiconductor counterpart of the thyratron.

Transistors are divided into two classes—the junction and point-contact or whisker types—according to the barrier used, *Fig.* 1.

Words like "triode" and "tetrode" designate the number of electrodes. Typical examples of this nomenclature are: point-contact transistor triode and junction transistor tetrode, or in short, point-contact triode and junction tetrode.

At present only the junction and the point-contact triodes are commercially available, both in a variety of types. These basic types differ considerably in such design aspects as power gain, maximum power dissipation, and switching time.

Junction triodes are available in two different froms; n-p-n and p-n-p transistors where n stands for negative and p for positive. The schematic symbols for these two types are shown in *Fig.* 2. They are almost identical except that the direction of all currents and voltages is reversed. If the n-p-n transistor corresponds to an electron tube with ordinary (nega-

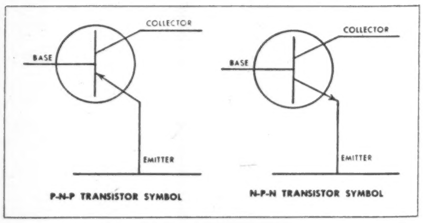

Fig. 2 — Schematic symbols for n-p-n and p-n-p triode transistors

tive) electrons as charge carriers, then the p-n-p transistor would correspond to a tube with positive instead of negative electrons. Since such a tube cannot be built, the availability of n-p-n and p-n-p transistors is, therefore, one of the unique features.

Transistor Circuits: Since transistors are similar to vacuum tubes, circuits using transistors are similar to circuits using electron tubes. Ways of thinking and methods of analysis can often be transferred directly from one field to the other. One reason is that both vacuum tubes and transistors can be represented with good approximation by active linear networks (equivalent circuits) so that the theory of these networks can be applied to both. But a number of differences do exist and, as a rule, electron tubes can't be replaced by transistors if the rest of the circuit is left essentially unchanged.

Temperature Considerations: At one time, germanium transistors were rather sensitive to variations in temperature. But now, because of recent improvements, junction transistors can be operated at ambient temperatures up to 110 C, and point-contact transistors up to somewhat lower temperatures. It should also be noted that some parameters of transistors will change at temperatures considerably lower than those at which the transistors become inoperative. However, with careful design it is possible to design equipment that will operate uniformly over a temperature range of 0 to 110 C.

At the present time, effort is being made to supplement germanium with silicon in semiconductor devices. It is believed that this will eliminate the problem at lower temperatures and permit operation at much higher temperatures.

Transistors vs Electron Tubes: Today the transistor is competing with the electron tube for the market in electronic equipment. Technically, transistors have a num-

(*Continued on Page* 290)

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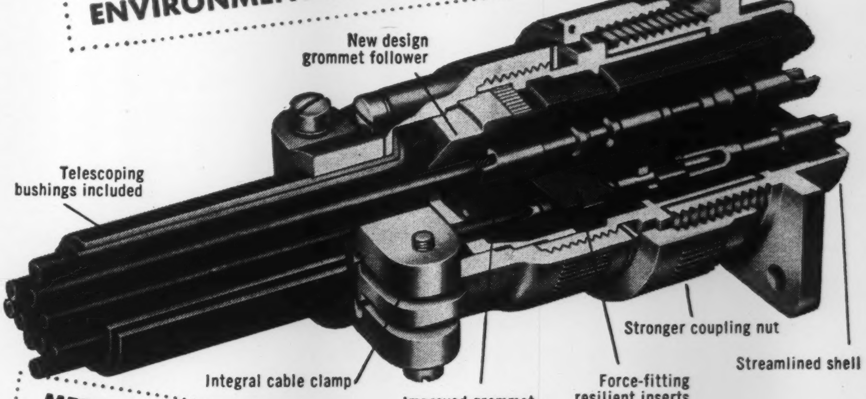
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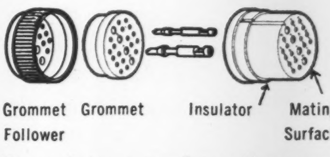

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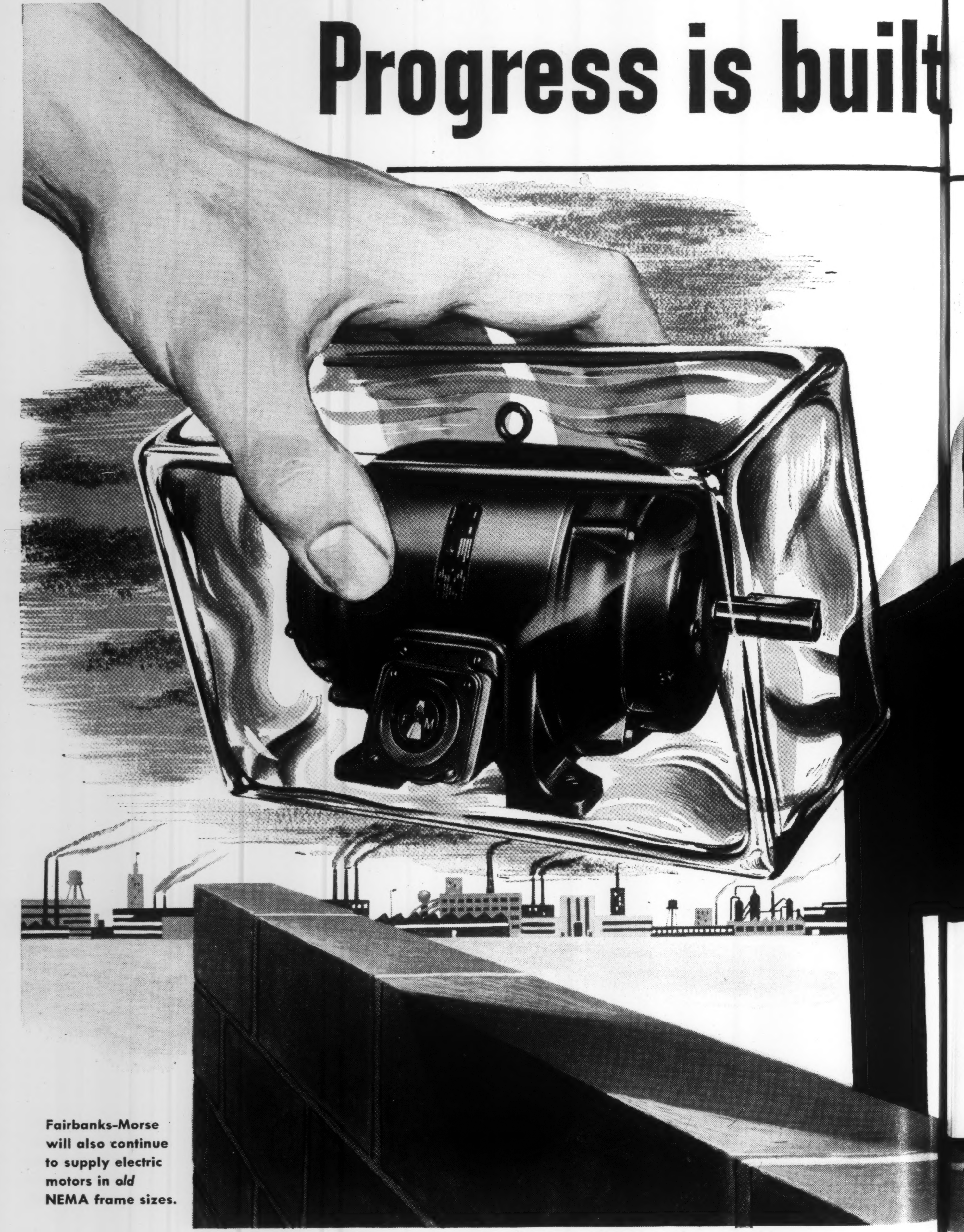

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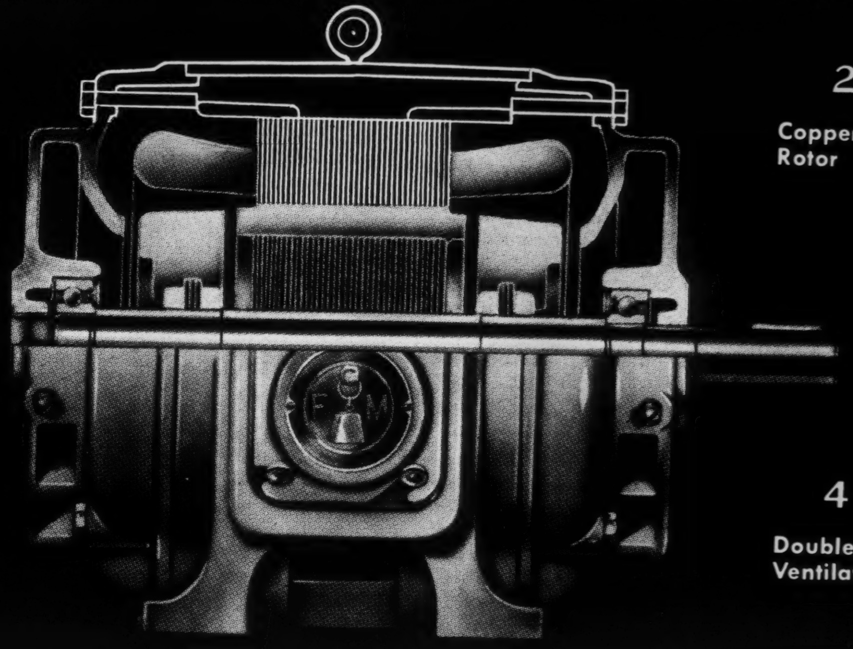

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Design Abstracts

(*Continued from Page* 287)

ber of important advantages over electron tubes, but it is hard to say which is the most important.

High reliability is the primary advantage of the transistor. No reason is known why a carefully manufactured, hermetically-sealed transistor should ever deteriorate in its performance. Even if experiments should show that transistors fail under extreme conditions after a number of years, it would still not be a sudden failure but, rather, a slow deterioration of performance over a period of many months. This could easily be detected by periodic checks. Early transistors were sealed in plastics, but the trend is toward hermetic seals to insure high reliability.

The fact that no cathode heaters are needed is another advantage of transistors. This means that they can operate at power levels of a fraction of a milliwatt, and stand-by operation is possible at a fraction of the maximum output power. This is vitally important where power is at a premium, for example, in battery-operated equipment. Furthermore, undesirable feedback and heater hum are eliminated. The absence of the heater also simplifies wiring and results in savings because a smaller power transformer is used.

Other advantages of transistors include operation from low dc supply voltages (as low as one volt), small size, and the availability of

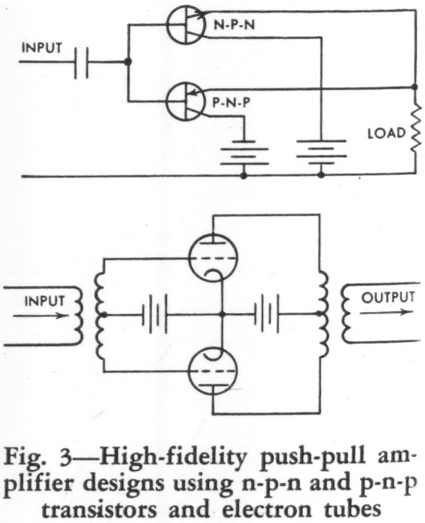

Fig. 3—High-fidelity push-pull amplifier designs using n-p-n and p-n-p transistors and electron tubes

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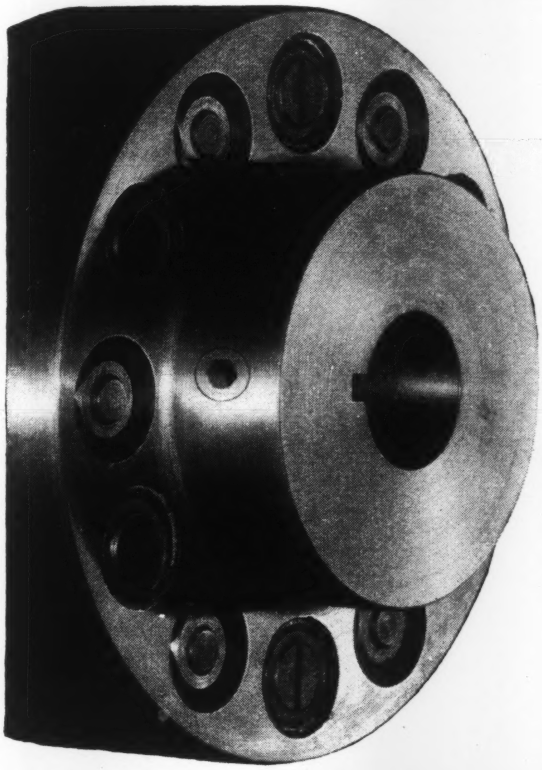

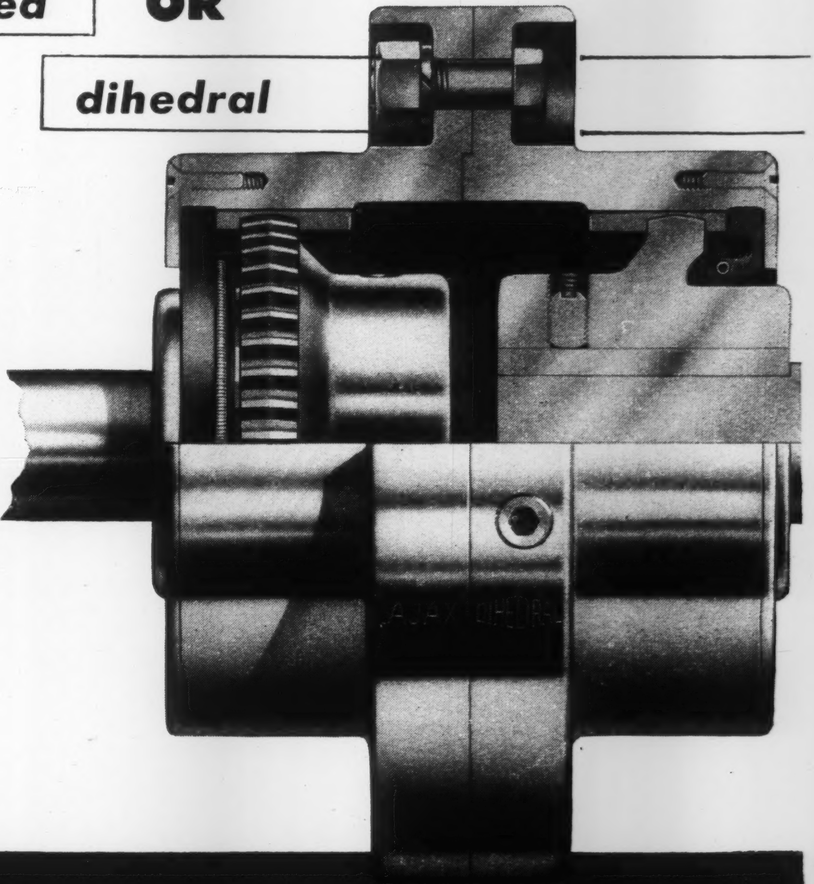

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both n-p-n and p-n-p types. This last advantage is quite important. It permits the design of simple circuits with a minimum of components. For example, an n-p-n and p-n-p transistor in parallel can operate as a push-pull amplifier without input or output transformer, *Fig.* 3. Such amplifiers, with their high efficiency and low distortion, are often used for high-fidelity record-playing equipment.

Because of the low power dissipated as heat in most transistor circuits, they may be packaged together in a small space without any danger of overheating—another important advantage to designers.

At the present time transistors are manufactured in relatively small quantities by rather expensive pilot-line methods using comparatively little automatic machinery. Under these circumstances, it is not too surprising that they are more expensive than comparable electron tubes. But because transistors have a relatively simple structure, they will ultimately be manufactured at lower prices than electron tubes.

Transistor Applications: Transistors, because of their desirable properties, shortly will replace electron tubes to a large extent in such items as communication equipment, computers, radios, and television receivers.

At present, transistors are limited in power output and frequency response; therefore, they can replace electron tubes only in a limited number of functions. For example, at present it would be impractical to use transistors in a 30-megacycle amplifier for radar applications because of the small power gain of commercially available transistors at this frequency.

Only in a few items—hearing aids, for instance—is it practicable to replace all electron tubes with transistors. Usually only a few electron tubes can be replaced with present transistors so that the equipment circuits are mixed.

As improved types of transistors are put on the market, it will be possible to replace more and more electron tubes in equipment. How-

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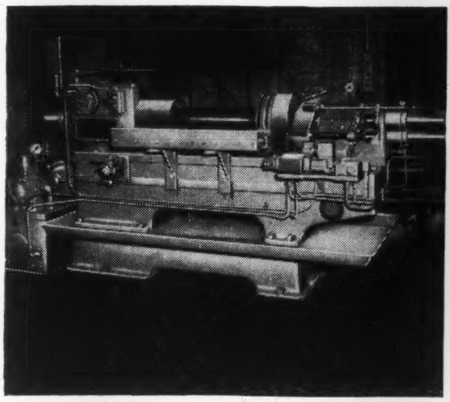

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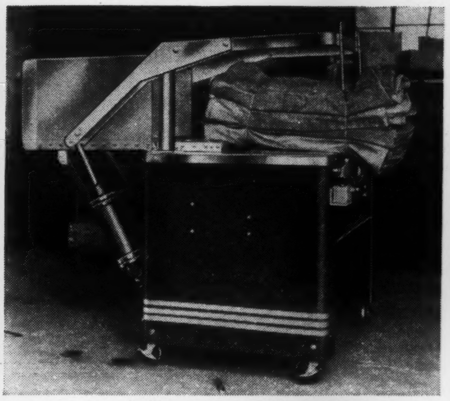

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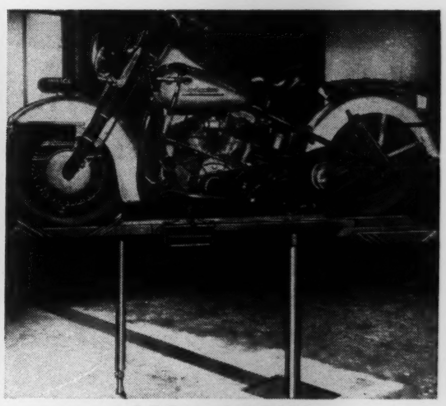

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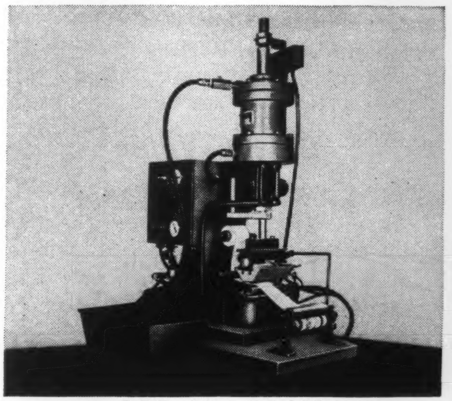

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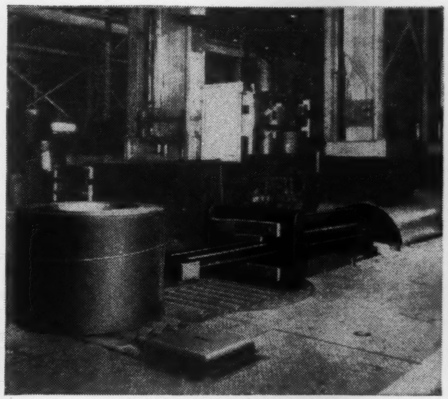

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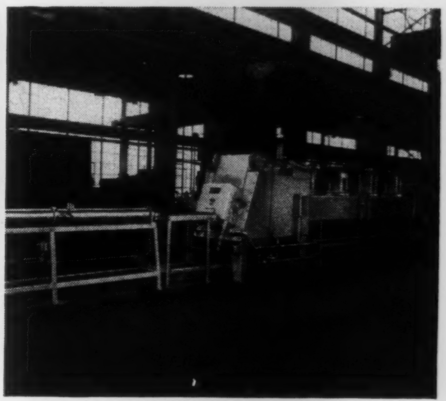

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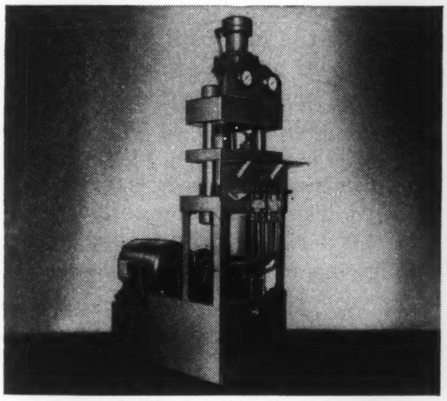

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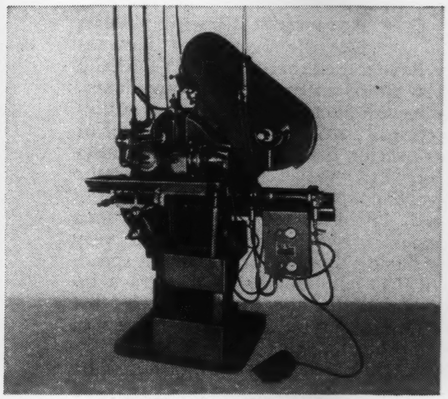

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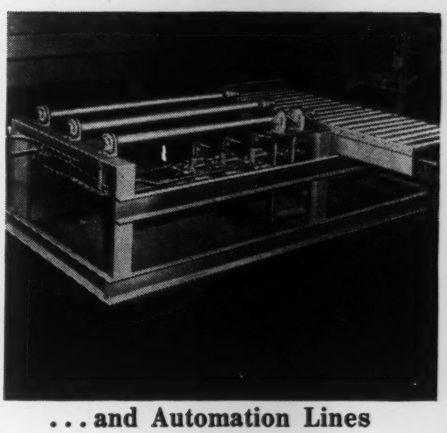

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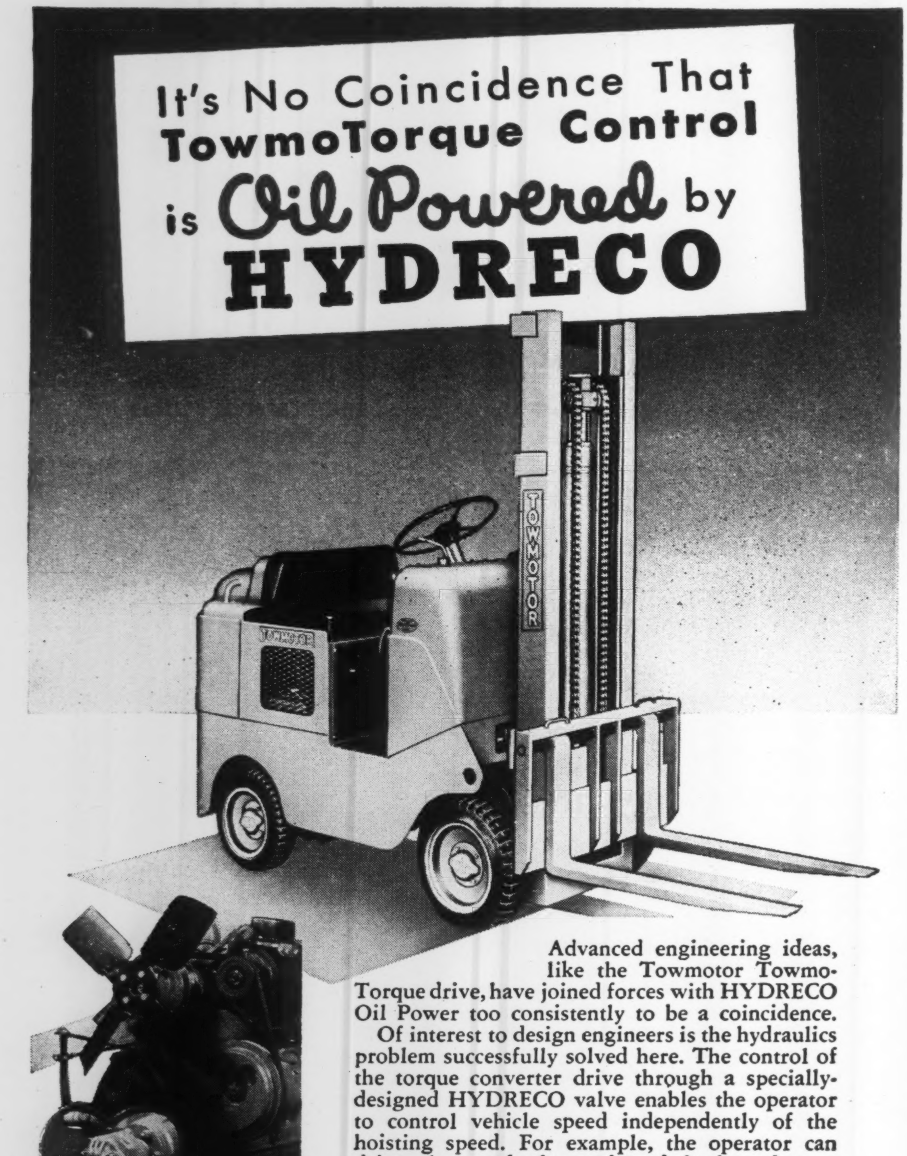

It's No Coincidence That TowmoTorque Control is Oil Powered by HYDRECO

Advanced engineering ideas, like the Towmotor TowmoTorque drive, have joined forces with HYDRECO Oil Power too consistently to be a coincidence.

Of interest to design engineers is the hydraulics problem successfully solved here. The control of the torque converter drive through a specially-designed HYDRECO valve enables the operator to control vehicle speed independently of the hoisting speed. For example, the operator can drive the truck forward and backward very slowly while raising the load at maximum speed. Other HYDRECO components on this truck include a special cylinder and relief valve for the TowmoTorque, and a pump, control valve and cylinder for the hoist circuit.

HYDRECO Oil Power is providing a definite sales advantage to more and more makes and models of mobile equipment, machine tools and special machinery. And, frequently you'll find that the things you're dreaming up are problems already solved by HYDRECO engineers.

The famous HYDRECO Four-Bolt design gear-type Pump for 1000 to 1500 psi applications is the heart of the Towmotor hoist circuit.

A compact HYDRECO cylinder designed with low-friction characteristics actuates the TowmoTorque drive.

This HYDRECO relief valve is used on the torque converter to protect the heat exchanger from excess pressure.

Located beneath the floorboards is the HYDRECO-designed valve, one plunger of which is connected to a hand lever and hydraulically controls the forward and reverse motion of the truck. The other plunger, connected to a foot pedal, controls the vehicle speed regardless of engine speed.

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ever, it is not expected that a complete replacement of electron tubes by semiconductor devices will ever be technically possible or economically practical.

There is another important facet to the application story. In addition to replacing electron tubes in existing equipment, there will, of course, be uses where electron tubes would not be practicable.

From an article entitled "Transistor Applications" which appeared in the General Electric Review for March, 1954.

Design Value of Extruded Steel

By S. O. Evans

Superintendent of Extrusion
Babcock & Wilcox Co.
Beaver Falls, Pa.

MUCH publicity has been given to steel extrusion in the last two years primarily because of interest aroused by using molten glass as the lubricant. This method, known as the Ugine-Sejournet process, has increased the length of billets and the ratio of the area reduction (extrusion ratio) available in steel and high temperature alloys. The real value of extrusion to the designer falls in one of the following categories:

1. Providing new metals that are difficult or impossible to work by previous methods.
2. Providing specially shaped tubes with outside and inside shapes which are not necessarily similar such as a tube with round outside and shaped inside or shaped outside and round inside, *Fig.* 1.
3. Providing solid shapes that are difficult or impossible to obtain by rolling.

Shape Considerations: When relatively small quantities of a new shape are desired, extrusion may well provide an economical source even when rolling is possible, but rolls are not presently available. Tools for extrusion can be produced for about $100 to $150 whereas rolls would cost much more.

There are many cases where 1000 pounds or less of a shape are required at intervals over a long period of time. Large quantities would cause a large investment to be tied up in the user's inventory, but a small quantity which must support the changeover of a rolling mill would be prohibitively expensive. In steel extrusion, the die is changed after every push so that successive pushes may well produce different shapes. Thus, an item as small as 150 pounds or one small billet may be produced as inexpensively as much larger quantities, assuming that the requirement is recurrent so that the die may be used up and its cost may be borne over a succession of such small items.

Mechanical Limits: The actual size of parts which may be extruded is determined by press design and container tools available. Overall dimensions of the shape must fall within a circle which will allow enough die wall between shape and container wall to give adequate die strength. A web thickness of about 0.100-inch is a minimum consistent with die filling and tolerable die wear, at least in the containers used thus far. Corner radii of 1/16-inch on outside corners and 3/16-inch on inside corners have been held without prohibitive die wear problems.

Dimensional Tolerances: Before generalizing on the tolerances available it is best to point out some of the factors surrounding such a generalization. First, since dimensional error results from die wear, the stringency of tolerances

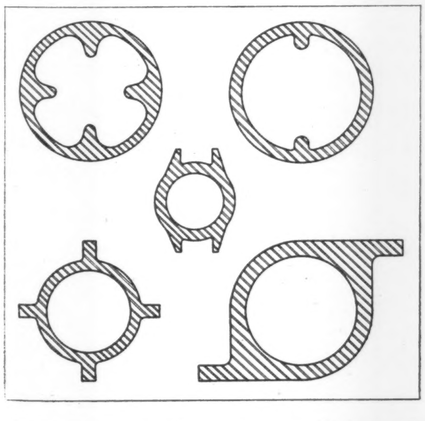

Fig. 1—Examples of extruded steel tubes with special inside and outside shapes

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is tied in with die cost for the extrusion. A loose specification will result in longer die life and lower costs. Second, since die wear produces dimensional variation, a section having small area (high extrusion ratio) causes high extrusion pressure, high die wear, and rapid dimensional variation which is difficult to tolerate on a small section. Finally, certain portions of dies such as sharp internal corners, wear more rapidly than other portions so that some dimensions in a specific shape will be more difficult to hold than others. For example, sections having an area of one square inch or more with no sections under 1/8-inch in thickness may be produced with reasonable die life to commercial hot-rolled tolerances in normal carbon steel and stainless grades. As the area and section thicknesses increase this comparison will be more favorable to extrusion.

Economic Considerations: The discussion of economic considerations and the outlining of fields of application of extrusion are closely related. The field of application for extrusion is just outside the field of commercial hot rolled shapes, and this is dictated by economics. Extrusion is an expensive process in comparison to commercial hot rolling. To support this expense in normal grades, the extruded product must yield savings someplace else along the line. In the extrusion of stainless steel tubing for subsequent cold working this saving results from elimination of expensive grinding on the inside of the tubes. Savings may be yielded by avoiding the use of expensive materials which either break up excessively or suffer excessive chip loss in machining. Also savings may accrue by eliminating costly machining operations.

Where reduction of machining of a shape is a source of savings, generally a breakdown of the operation will show the machine cutting time is high as compared with set-up time, because the extrusion tolerances will probably be such that the set-ups and minor machining will still be necessary.

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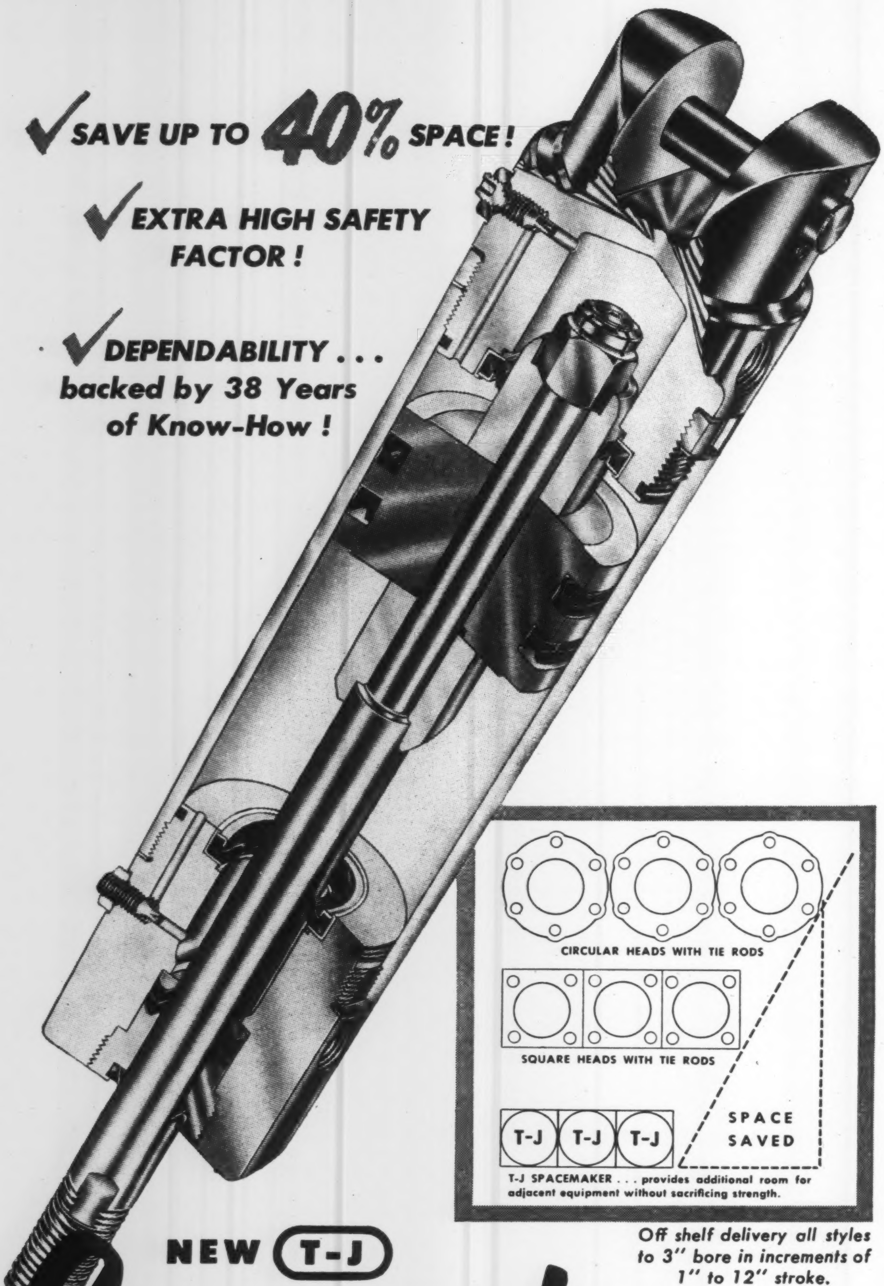
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from other sources. Such a product might be seamless tubes in grades such as 19-9DL, 44OC, or type 309. Actually, however, some of these items are now extruded which were economically unobtainable because of the prohibitive loss on the mills or the excessive cost of producing the part by pure machining.

From a paper entitled "Steel Extrusion and Its Value to the Designer" presented at the SAE National Passenger Car Body & Materials Meeting in Detroit, Mich., March, 1954.

Evaluating Electric Rotating Regulators

By G. E. Shaad
Industrial Engineering Sec.
General Electric Co.
Schenectady, N. Y.

ACTUALLY, there are few designs of equipment that could properly be termed "rotating regulators". The three-brush, battery-charging generator used on automobiles a few years ago was nearly a true rotating regulator. Today's terminology of rotating regulators refers to the large number of specially designed dc generators and circuitry used as amplifiers in regulating circuits. These units are used primarily in closed-cycle control and are designed to meet the requirements of an amplifier in a regulating system.

Basically the rotating regulators are of either the amplidyne type (armature-reaction excited) or the self-energized type (such as the Regulex, Rotatrol or VSA units) where a shunt or series field or a combination of the two is used to provide most of the required excitation. Although they differ greatly in their design fundamentals, both types of equipment provide control from a small amount of excitation. Without going into detail, the basis for the self-excited unit design (either series or shunt self-excitation) is shown in *Fig.* 1.

In the late 1930's a new rotating regulator called the amplidyne was introduced. This machine established a new criterion for rotating

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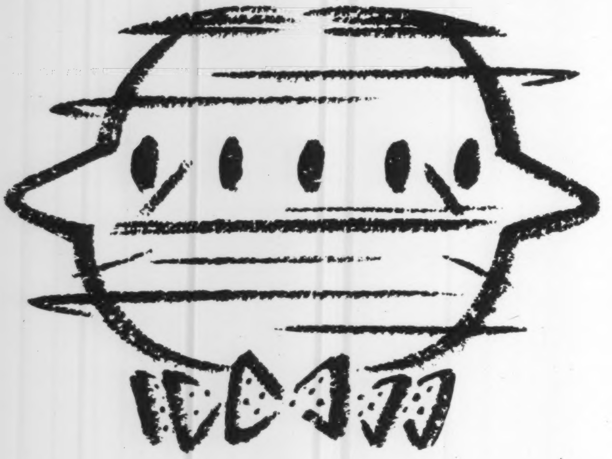

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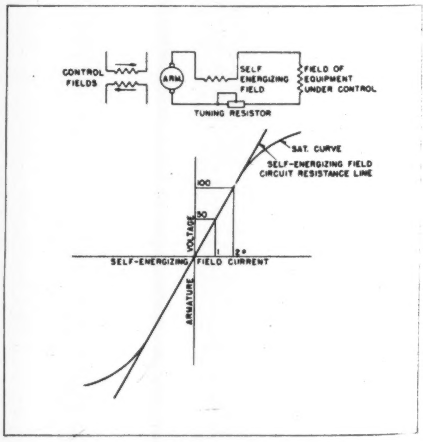
regulators since its speed of response was fast and its small excitation requirement made it suitable for many regulator applications that had not previously been considered. In addition to its response and excitation characteristics the amplidyne's ability to perform double amplification in one piece of rotating equipment made the construction of this type of unit economically feasible in larger sizes than had previously been contemplated.

The amplidyne design as shown in *Fig.* 2 consists of a dc machine structure with a pair of short-circuited brushes, a pair of load brushes, a compensating winding, and one or more control fields. A small amount of control excitation, establishing a small flux, can circulate full-load current through the short-circuited brushes. This current sets up a large armature-reaction flux and the resultant voltage is used for the load circuit. Because current flow in the load circuit would produce an armature reaction opposing the control field flux, a compensating winding is used to maintain the control flux under load conditions. Although a theoretical power amplification of many thousands is possible, practical circuit applications dictate more reasonable goals.

All dc amplifiers and control systems have limitations and rotating regulators are no exception. For most industrial applications the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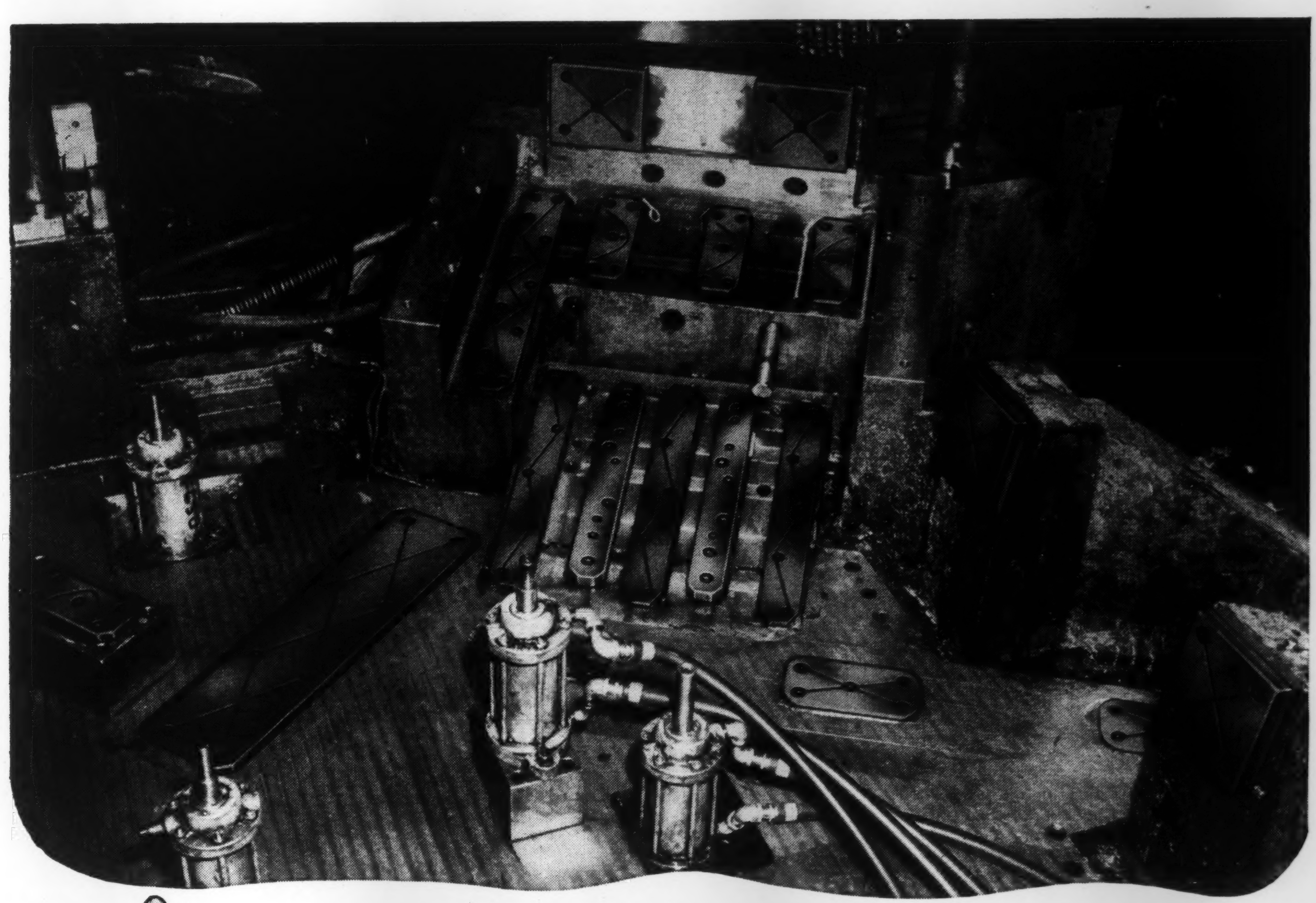
SELF ENERGIZING FIELD
FIELD OF EQUIPMENT UNDER CONTROL
TUNING RESISTOR
SAT. CURVE
SELF-ENERGIZING FIELD CIRCUIT RESISTANCE LINE
100
30
ARMATURE VOLTAGE
1
2
SELF-ENERGIZING FIELD CURRENT

Fig. 1—Basic self-excited rotating-regulator circuit and excitation curve



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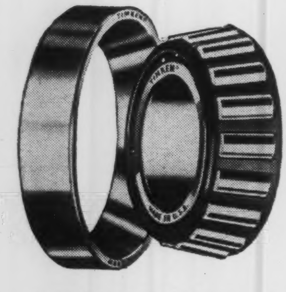

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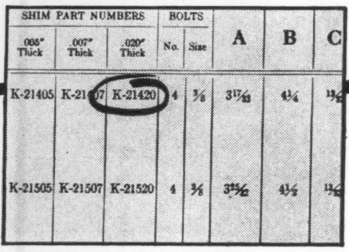

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disadvantages are not of major importance but they should be considered.

Space and Weight: Rotating regulator systems are not particularly light or small and thus may not be satisfactory for applications where weight and space are limited.

Amplification: A rather significant amount of control power is necessary for rotating regulators. In general, the systems seldom use less than 3 to 4 watts of control power and usually use 30 to 40 watts. Either magnetic or electronic preamplifiers may, however, readily be used to reduce the amount of control power as far as is necessary.

Time Constant: Although rotating regulators are fast in response, they do involve a time constant that must be considered in complex systems.

Flexibility: In general, the flexibility of rotating regulator systems is excellent. Nevertheless, the fact that they require excitation power makes major system changes involve considerable material.

Life Expectancy: Each rotating regulator is nothing more or less than a small dc generator with its associated commutator, brushes, and bearings. For units properly maintained and under reasonable

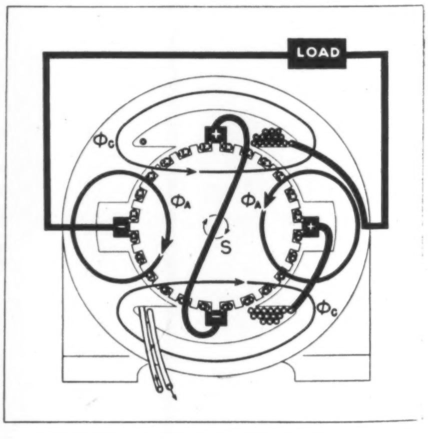
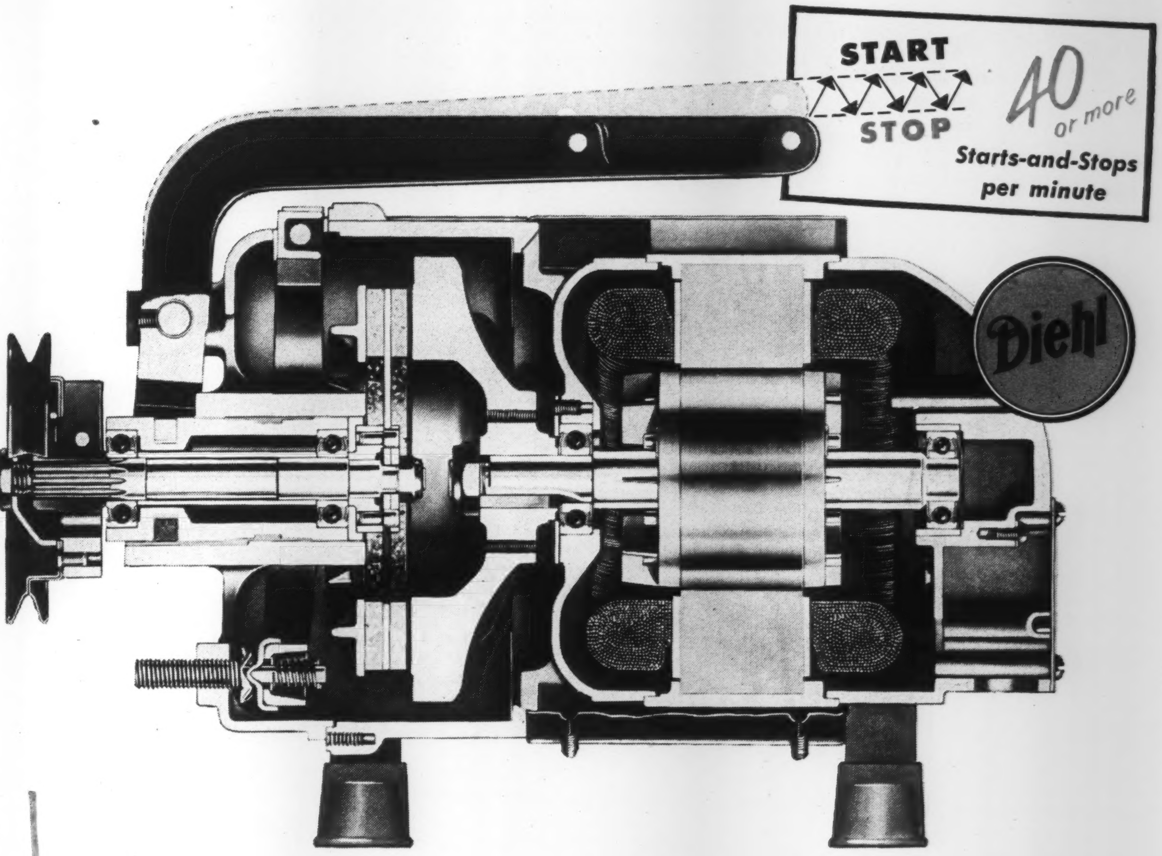


Fig. 2—Amplidyne rotating generator or regulator



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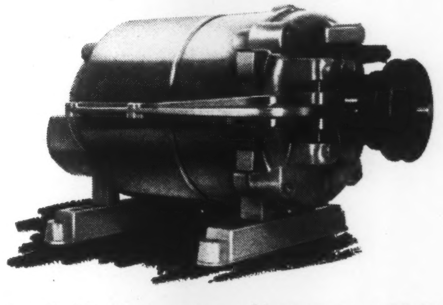

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conditions of operation, a life of 20 years should easily be obtained. Where the units are poorly maintained or put in impossible locations, failure can be expected the same as on any system.

Independence from Outside Power: Perpetual motion rotating regulators are not made, of course, but the stored energy of the rotating equipment is often used to overcome difficulties that might be encountered in the event ac power is lost. On amplidyne-controlled log-carriage drives, for example, the regulating system provides reversing voltage control with acceleration and deceleration current limits. If ac power is lost for any reason, the stored energy of the carriage must be absorbed by the motor-generator set and the carriage stopped before it reaches the end of its travel to prevent equipment damage. Since the exciter, the amplidyne, and the generator are all part of the same motor-generator set both excitation power and regulator power are available for safe stopping.

Isolation of Input and Output: Since any rotating regulator is controlled through its magnetic circuit, it is easy to provide system isolation. Such isolation increases the control power requirement but permits little difficulty in solving normal regulating problems. Also, this isolation provides increased safety or increased flexibility in many regulating systems.

Input Signal Filtering: The ability of rotating regulators to be self-filtering and thus be sensitive only to the average value of input signal eliminates any input signal filter problems.

Dc Output: The rotating regulator can motor or generate as the occasion requires. Thus the load on the rotating regulator can readily be a motor armature or can be used to fill generating or regenerating needs.

In addition, the low armature resistance combined with the ability to pass current in either direction will often allow considerable cir-

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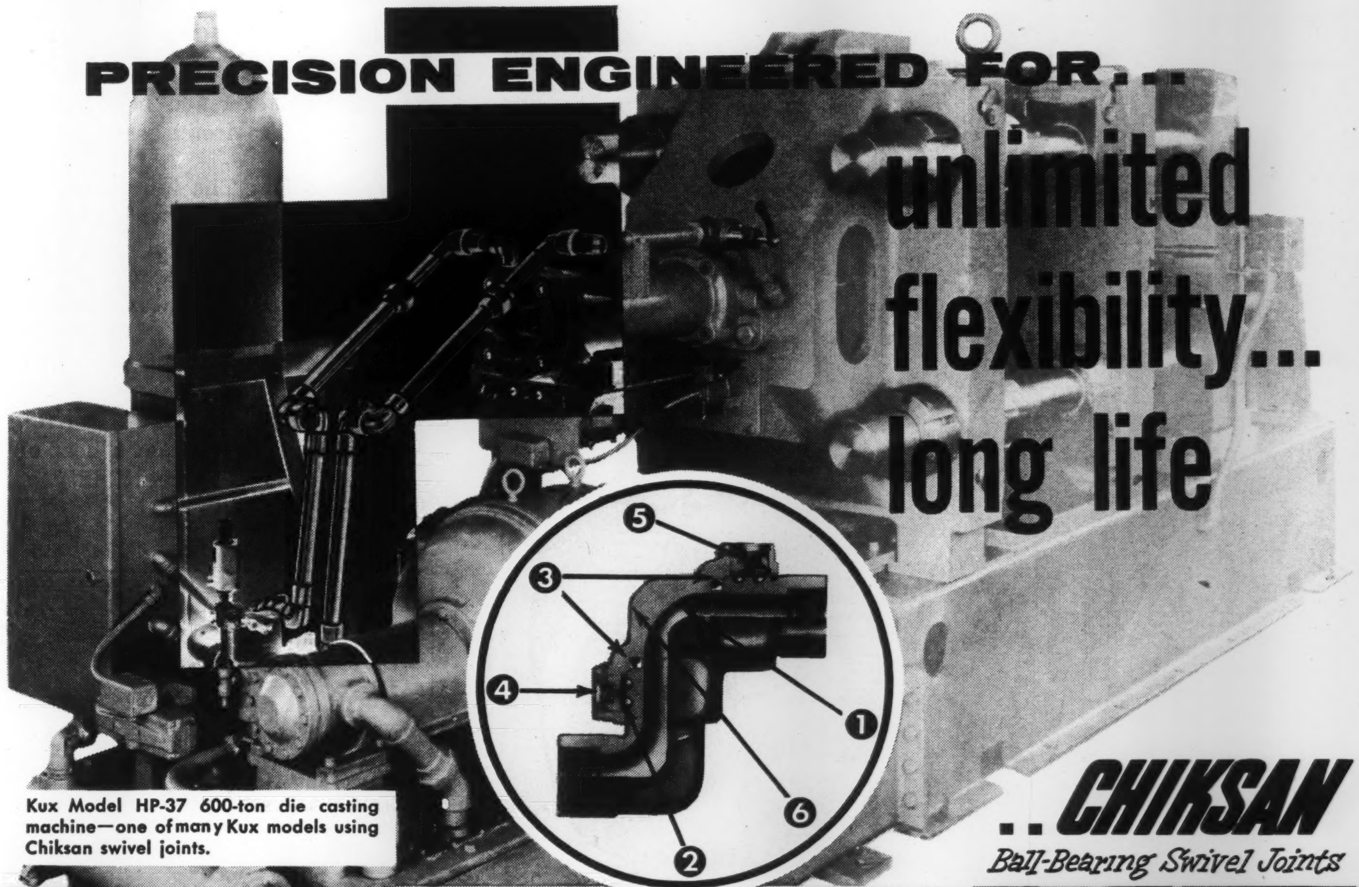

Kux Model HP-37 600-ton die casting machine—one of many Kux models using Chiksan swivel joints.

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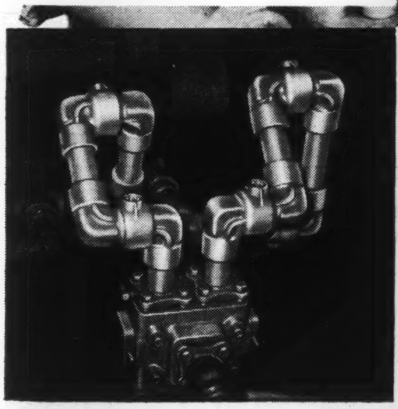

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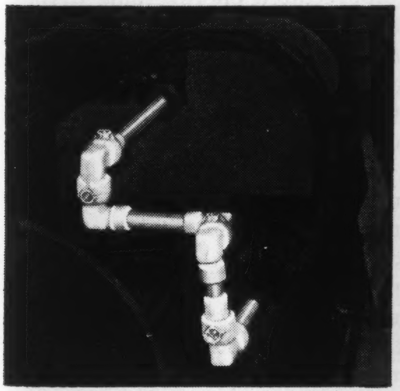

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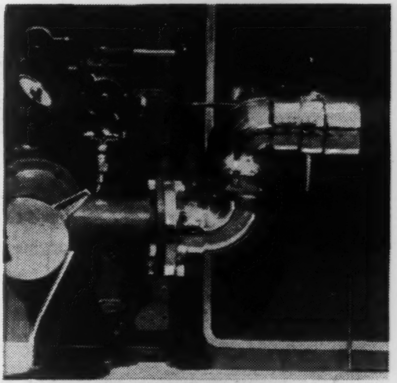
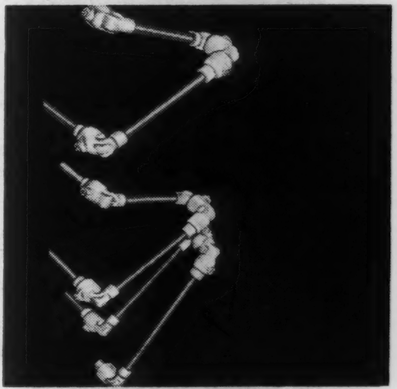


Chiksan swivel joints on fire department trucks provide increased hose flexibility and save on hose wear.



Chiksan high-pressure swivel joints provide flexibility and eliminate danger of ruptured steam lines on platen presses.

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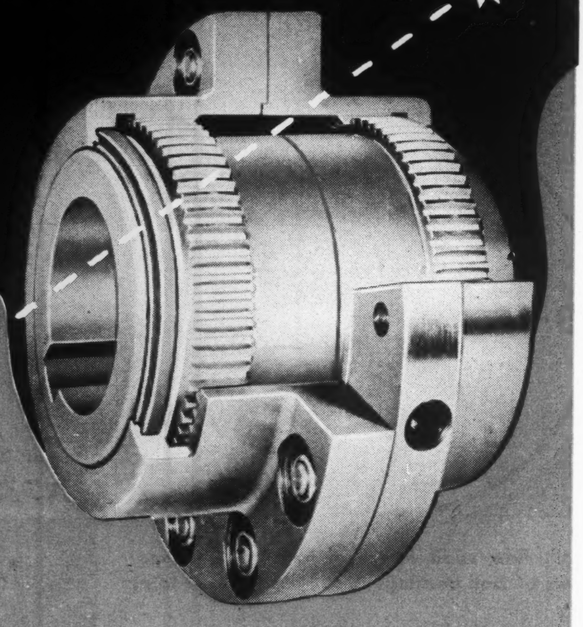

cuit simplification and better utilization of other circuit components.

Reversibility: The inherent ability to reverse polarity with nothing more than a reversal of excitation polarity is an outstanding advantage of rotating-regulator systems. On reversing systems, such as log-carriage drives, arc-furnace control, machine-tool tracer control, reversing cold-strip mill control, power-shovel control and a host of other systems, the reversibility of rotating regulators minimizes the equipment and simplifies the system.

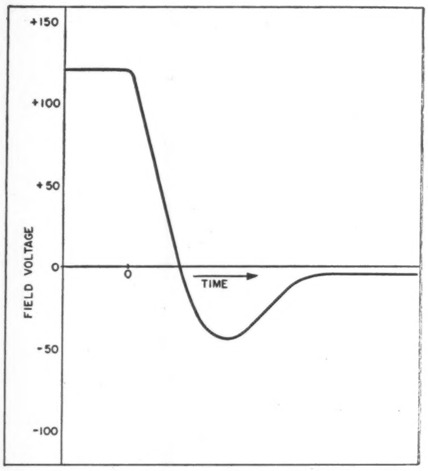

Fig. 3—Curve of applied field voltage during regenerative braking for rotating regulators

The need for such ability is readily appreciated on reversing drives but few engineers realize that many nonreversing drives benefit from the same ability to reverse polarity. A paper-mill rewinder drive, for example, does not require operation in reverse rotation. Many such winders, however, require rapid regenerative braking stops and all such winders should have the main generator voltage at a low level when power is first applied. The rotating regulator can push the generator field voltage down not only to zero but as far negative as may be required to obtain the necessary field forcing on rapid stopping, *Fig.* 3. Likewise the generator residual voltage can readily be reduced by slight negative gen-

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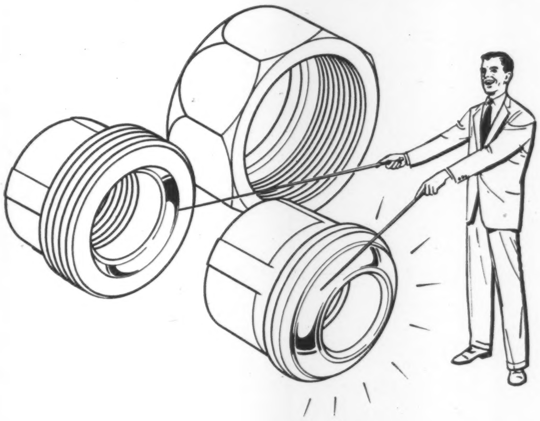

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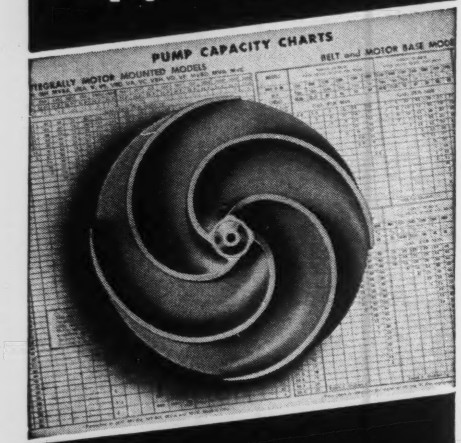

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erator field excitation from the rotating regulator.

From a paper entitled "Industrial Regulating Systems Using Rotating Regulators" presented at the AIEE Winter Meeting in New York, N. Y.

Silicone Rubber Design Characteristics

By G. W. Painter

Research Engineer
Lord Mfg. Co.
Erie, Pa.

THE unusual high and low-temperature properties of silicone rubber have made it a desirable material for vibration isolators designed for service at temperature extremes. In general, silicone cannot be substituted directly for such elastomers as natural rubber and neoprene in established designs. This lack of interchangeability results principally from the lower tensile strength and the unusual load-deflection characteristics of the material.

Viscoelasticity: Application of sinusoidal strain to a viscoelastic material results in the generation of a resisting force. If the force-deflection relation is linear, the resisting force is also sinusoidal. Presence of internal friction causes a phase difference between force and strain. Total force can be represented as a vector which can be resolved into two components, one in phase with strain and one 90 degrees out of phase. These forces may be termed as elastic and viscous components.

Strain Effects: All elastomers are known to be permanently changed when they are subjected to strain. Quite often the effect of strain upon the viscoelastic properties is so slight that it is of no "practical" importance. The modulus of silicone rubber is markedly changed by strain, however. The elastomers investigated include silicone-rubber compounds SE450 and SE550 produced by the General Electric

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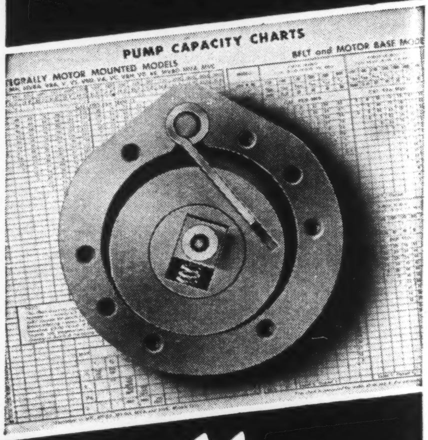

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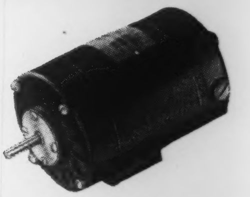

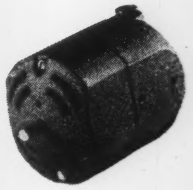

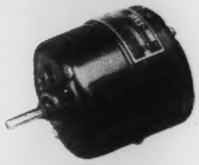

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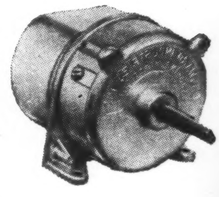
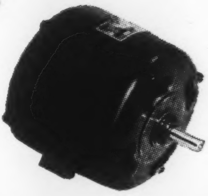
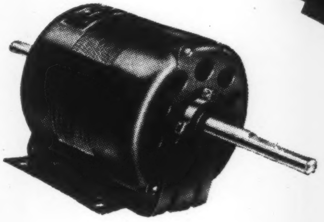




SHADED POLE MOTORS
1/2000 to 1/8 h.p.



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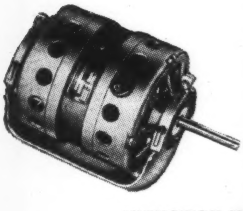
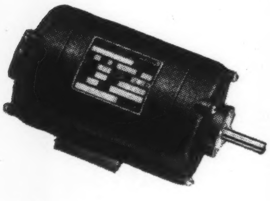


INDUCTION MOTORS
1/1400 to 1/4 h.p.



The eight Howard motors illustrated here are representative of the wide range of fractional H. P. motors available at Howard.

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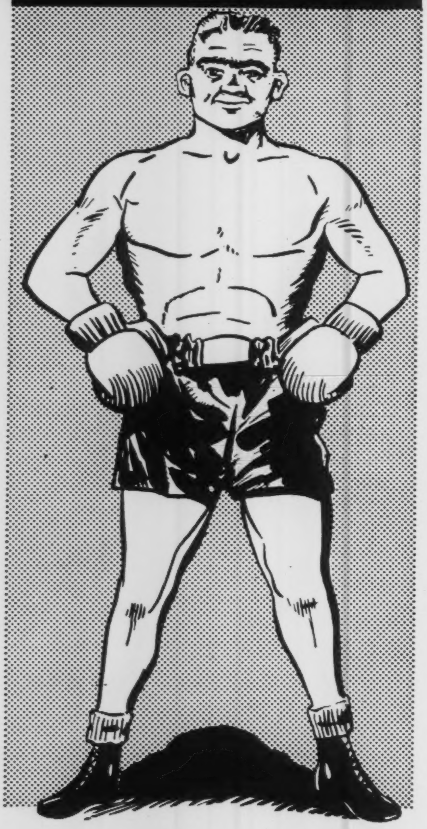

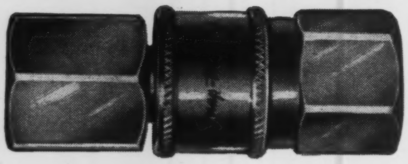

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Company, and a soft natural-rubber compound.

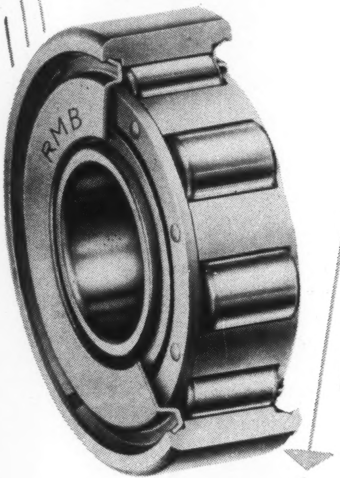
At strains which do not exceed 0.30-inch per inch the silicone rubber undergoes virtually no change in stiffness. As the degree of strain is further increased, the load-deflection curve exhibits an abrupt reduction in slope when the strain exceeds the maximum reached in a previous cycle. This behavior probably results from the rupture of various structural bonds either between the polymer and the filler or between the polymer molecules. Nearly all of the bonds can withstand a macrostrain of 0.30-inch per inch, but more and more of them break as the strain is increased beyond this value. A reduction in stiffness brought about by strain has been noted in natural rubber and neoprene, particularly in compounds employing a high carbon-black content. The structural breakdown in these elastomers is considerably less pronounced than in silicone, however, and the structure tends to rebuild partially if the material is allowed to "rest" for a few days. The breakdown in silicone is apparently permanent.

Strain Characteristics

Tests on the variation of dynamic elastic shear modulus with static shear strain indicated that the structural breakdown was reflected in the dynamic stiffness. The first cycle curves were run on previously undeflected test specimens by subjecting them to an increasing static strain while applying an alternating double-amplitude strain of 0.020-inch per inch. After reaching a static strain of approximately 0.95-inch per inch, the strain was reduced to zero, and the entire cycle was then repeated. The second cycles exhibited considerably lower dynamic stiffness.

Silicone compound exhibits a greater degree of nonlinearity in its modulus-strain curve than does natural rubber. Static strain has marked effect upon the dynamic modulus of the silicone compound. Amplitude of dynamic strain with-

HERE'S WHAT We MEAN BY-



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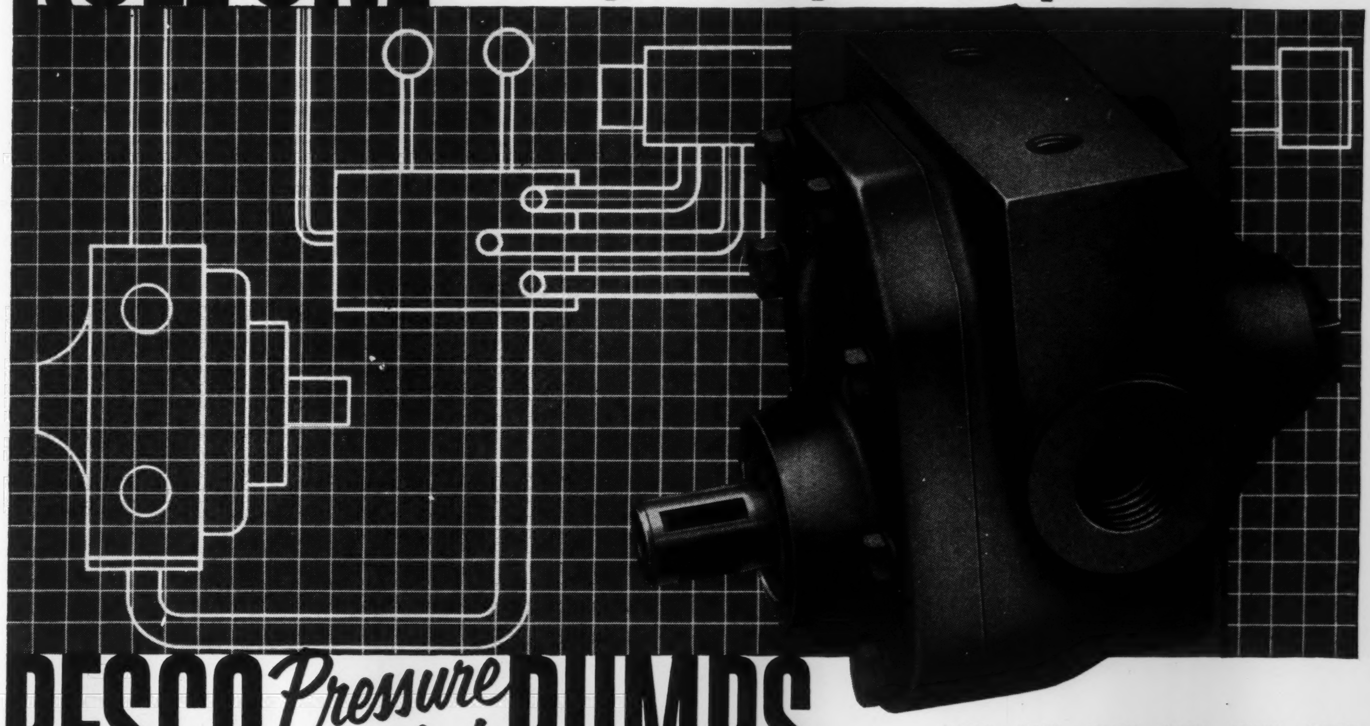

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in the range covered affects the dynamic modulus components of silicone and natural rubber similarly. The principal difference is a higher value of the viscous component exhibited by silicone rubber.

Temperature Effects: The most desirable characteristic which silicone possesses is its maintenance of room-temperature properties over an extended temperature range. A comparison between a 45 durometer natural-rubber compound and silicone compounds SE450 and SE550 in regard to the variation of dynamic modulus with temperature shows that both silicone compounds remain flexible at temperatures considerably below natural rubber. Compound SE550, designed especially for low-temperature flexibility, showed little change in elastic modulus even at −100 F.

Static Modulus: The term "static modulus" is, of course, a misnomer since static modulus tests are actually dynamic tests carried out at low velocities of strain. In comparing the static and dynamic modulus values of natural rubber and silicone-rubber compound SE450, the natural-rubber compound has a higher static modulus but a lower dynamic modulus than compound SE450. Throughout most of a frequency range of 1 to 3600 cpm the silicone compound has the higher dynamic modulus. At the lower frequency limit the modulus of SE450 falls below that of natural rubber.

Conclusions: The excellent low-temperature properties of silicone rubber provides the vibration-isolator designer with a material which will allow the isolator to function properly at −100 F. Although the modulus of the material is affected considerably more by static strain than is natural rubber, provision for this characteristic can be made in design.

From a paper entitled "Dynamic Characteristics of Silicone Rubber" presented at the Annual Meeting of ASME in New York, N. Y., December, 1953.

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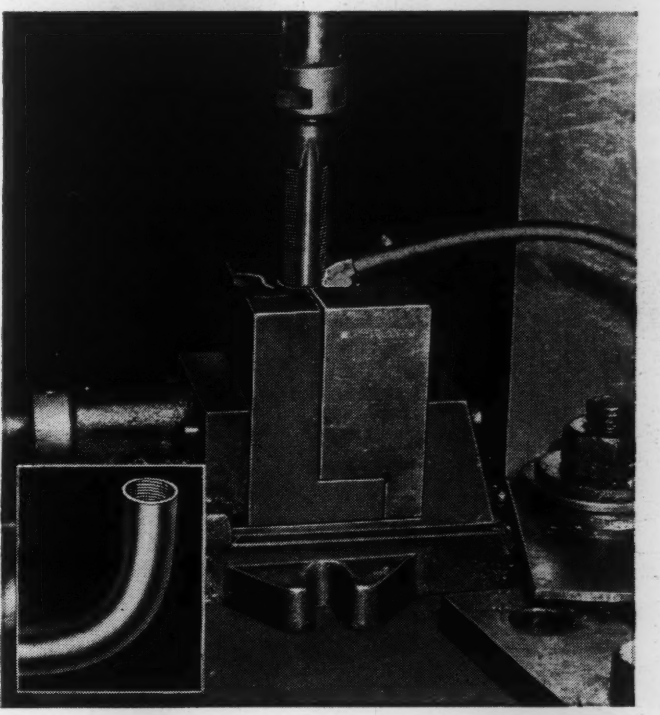

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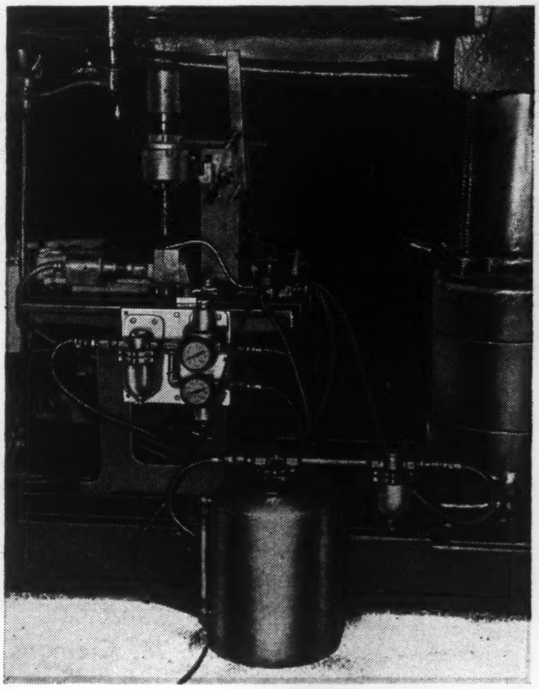

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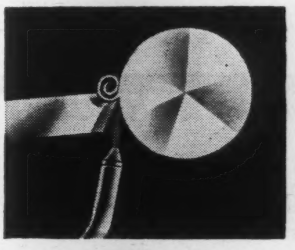

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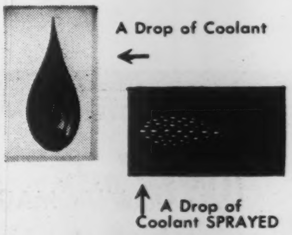

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MEN
OF MACHINES

Maurice M. Clemons has been appointed chief engineer of Sahlin Engineering Co., Birmingham, Mich. A graduate of the General Motors Institute, Mr. Clemons was associated with General Motors Corp. for 25 years. He served as a chairman of the Joint Industry Conference for punch press standardization in 1953 and is a member of the National Book Committee of the American Society of Tool Engineers.

Maurice M. Clemons

John Hamilton Crankshaw has been named vice president in charge of engineering of J. A. Zurn Mfg. Co. and the company's affiliates, American Flexible Coupling Co., and the Zurn Research and Development Co. of Erie, Pa. Mr. Crankshaw received his mechanical engineering degree in 1939 from Massachusetts Institute of Technology and his master's degree one year later. He specialized in machine design, with particular emphasis on the details of gear design. In 1940 he joined the General Electric Co., where he served most recently as head of the me-

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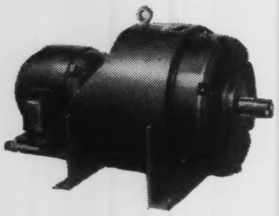

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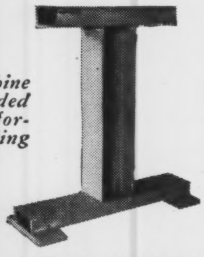

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Design Bulletins also available to product engineers by writing on your letterhead to

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DEPT. 1104, CLEVELAND 17, OHIO

Men of Machines

John Hamilton Crankshaw

chanical design section in the motor division at Erie, Pa. Mr. Crankshaw is a member of the American Society of Mechanical Engineers, the Society of Automotive Engineers, the American Society for Metals, the Association for Metals, the Association of Iron and Steel Engineers and the Society of Naval Architects and Marine Engineers.

Former research scientist with the U. S. Atomic Energy Commission, **Terrence H. M. Taylor** has been named chief engineer of the Nordstrom Valve Div. plant of Rockwell Mfg. Co. at Oakland, Calif. Mr. Taylor previously served three years as senior process engineer of Pabco Products Inc., a year as chief of project engineering and design drafting for Golden State Co. Ltd., and six years as director of development for Cutter Laboratories.

Chief engineer of the new Brewster, N. Y., plant of Donald P. Mossman Inc., is **George C. Hills Jr.** Prior to joining the Mossman company, Mr. Hills served as industrial specialist with the Department of Defense and had been assistant to the chief engineer of the Plastics Div. of Celanese Corp.

The appointment of **Charles F. McCabe** and **Joseph H. Famme** as assistant chief engineers in the San Diego division has been announced

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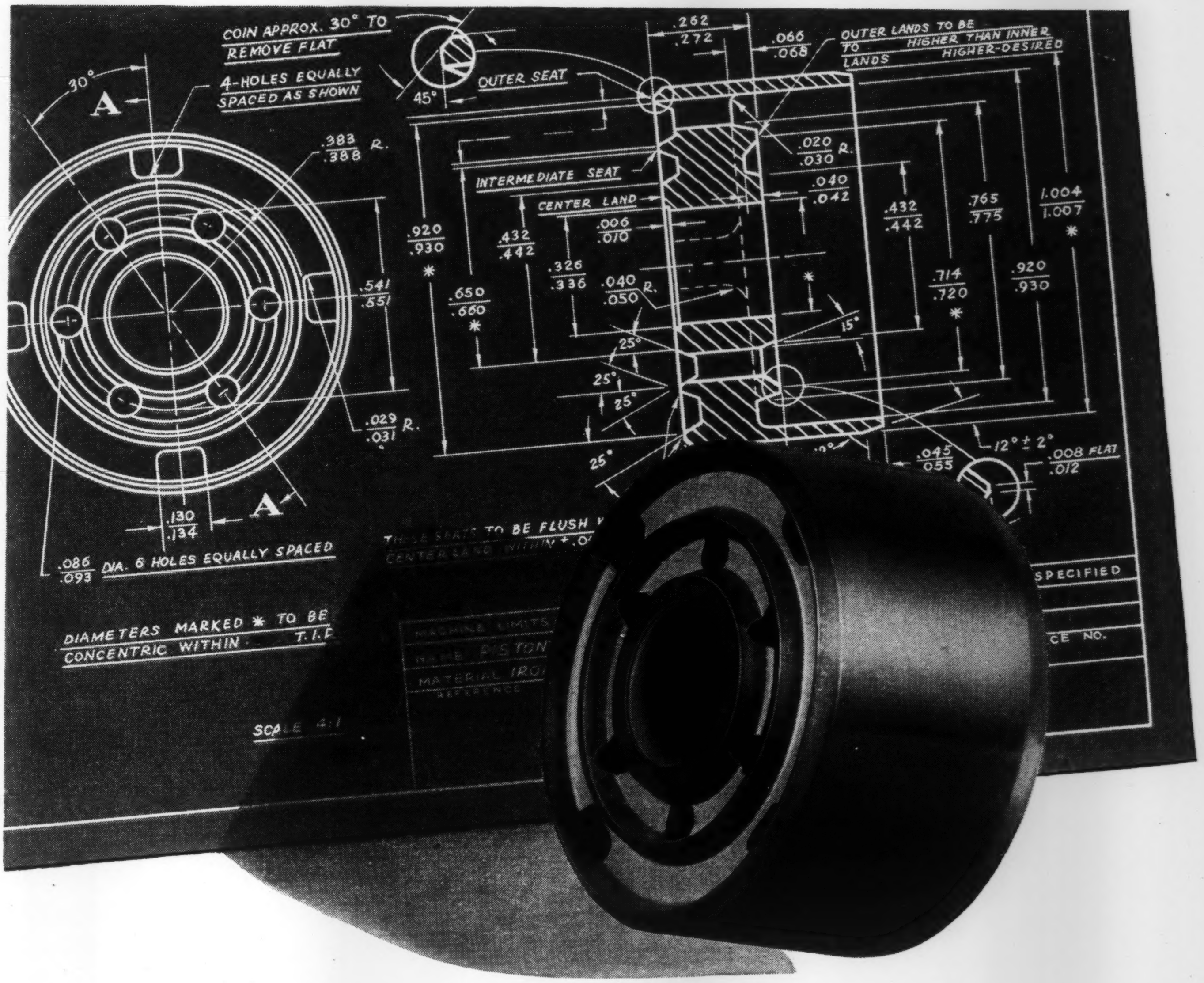
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.765 .775
1.004 1.007
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.326 .336
.040 .050 R.
.650 .660
.714 .720
.920 .930
15°
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.029 .031 R.
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A design can be so complex that the cost of making it by conventional casting and machining methods would be prohibitive. Yet, that same design can be produced by the Moraine metal powder process at moderate cost—usually in one press operation—with no drop-off in quality or precision.

For example, this part, of intricate design and close tolerances, is made in quantity every day at Moraine with very noticeable savings to the customer. It illustrates how much can be done to improve performance and cut costs when customer and Moraine cooperate to adapt part to process.

Moraine's experience with powder metallurgy is extensive and the possibilities it offers to modern industry are almost limitless. There are very few design ideas that cannot be profitably converted into practical parts by the Moraine metal powder process.

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How small is small? Anything from the size of a pinhead up to you-name-it. Universal has special skills for making these perfect peewee pellets. Write for details.

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

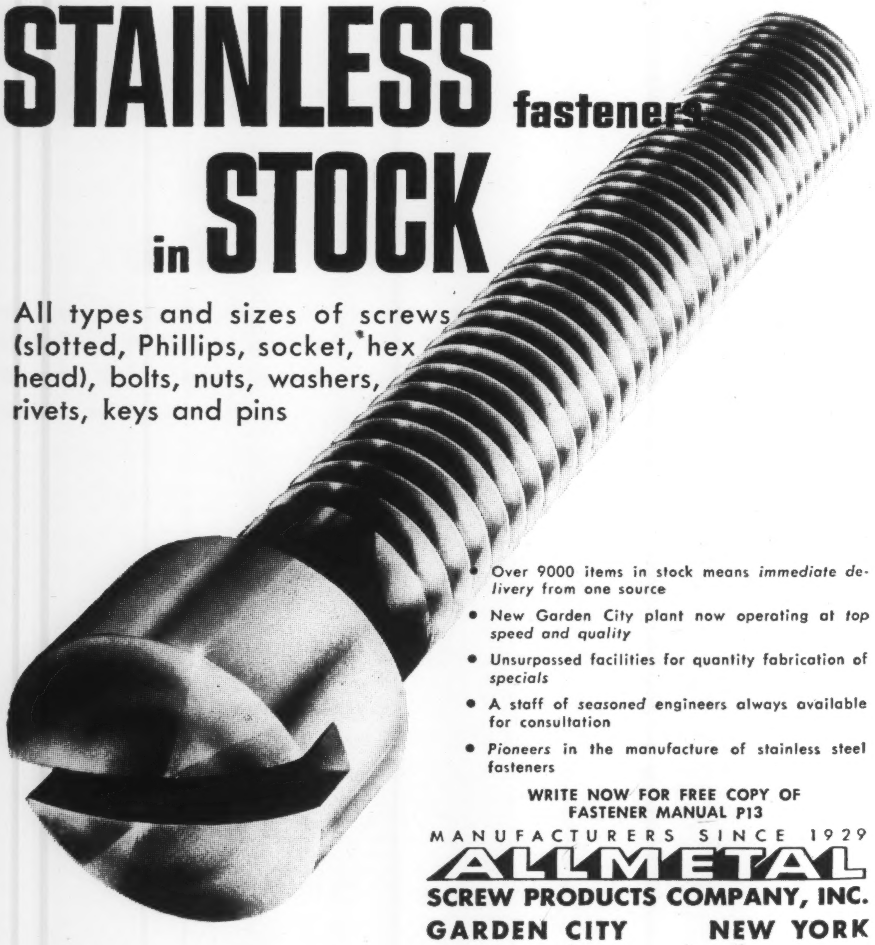
by Consolidated Vultee Aircraft Corp. Both men have been in the aircraft industry for 24 years. Mr. McCabe studied electrical engineering at the University of Washington, and before joining Convair was a design group engineer with Boeing Aicraft Co. He has since served as electrical design specialist; project engineer; senior design group engineer; and, most recently, as chief project engineer. Mr. Famme, a mechanical engineer, was a design engineer with Glenn L. Martin Co. before joining Convair. He held the position of chief project engineer before his new appointment.

Rolf Kroekel

Rolf Kroekel has been appointed director of research and development by Sealol Corp., Providence, R. I. He will direct the company's research program and will be particularly concerned with exploring the possibilities of new materials and new seal designs. Mr. Kroekel completed his formal education in Germany prior to World War II and subsequently worked in missile development programs, especially in the field of applied hydraulics. He has since filled engineering positions in Germany and in the U. S. Naval Ordnance test Station at Pasadena, Calif.

The promotion of **C. G. Mikkelsen** to supervisor of design engineering for the graphic products

STAINLESS fasteners in STOCK



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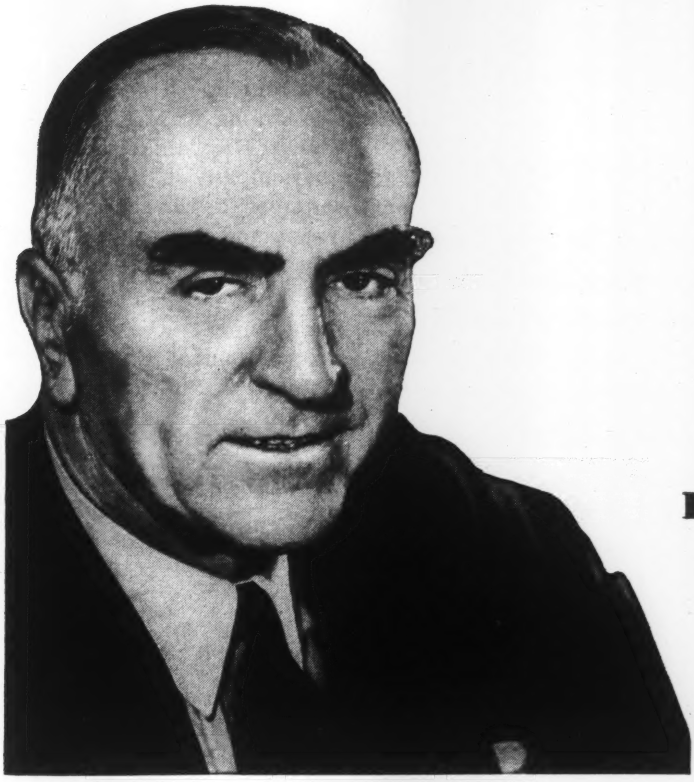

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TYPE WGR
TYPE WGRT

group was announced recently by Minnesota Mining & Mfg. Co., St. Paul, Minn. Mr. Mikkelsen, who joined the company in 1944, was a design engineer for the coated abrasives division and the graphic products group.

Sage Equipment Co., Buffalo, N. Y., has announced the appointment of **Morell C. Smith** to the engineering staff.

Paul M. Brown, A. P. Henry, Milton W. Huber, Stuart L. Sandelman and **Winthrop R. Wiles** recently joined the technical staff of the Hughes Research and Development Laboratories, Culver City, Calif.

Formerly assistant manager of the engineering department of Allen B. Du Mont Laboratories Inc., Clifton, N. J., **Humbert P. Pacini** has been promoted to manager of the department.

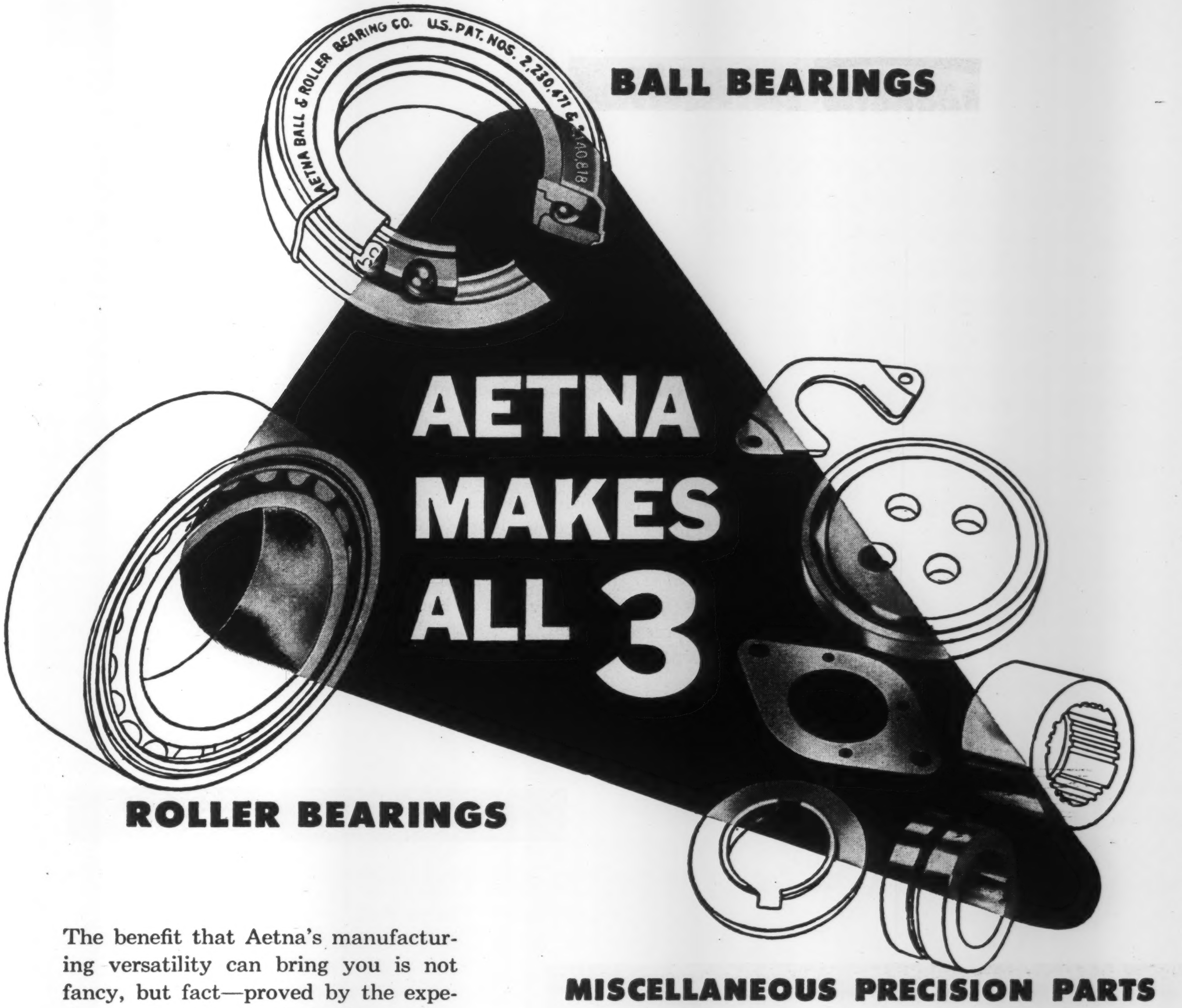
Donald P. Berg has been promoted to senior project designer at Designers for Industry Inc., Cleveland.

Dr. Robert H. Eustis has joined the physics staff of Stanford Research Institute. He previously served as chief engineer of Thermal Research and Engineering Corp.

William D. Bell has been appointed manager of special products at Boston Gear Works, Quincy, Mass. He will head a department established recently for handling special, nonstandard gears.

Charles C. Smith has joined Roll Forming Corp., Shelbyville, Ky., as manager of operations, with duties which will include supervision and co-ordination of production and engineering of roll-formed shapes. Mr. Smith was formerly associated with the General Electric Co.

John A. Gilbreath has been named division manager of the new Air Conditioning Div. of Westinghouse Electric Corp. at Staunton, Va. Mr. Gilbreath comes to his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The benefit that Aetna's manufacturing versatility can bring you is not fancy, but fact—proved by the experience of the nation's leading manufacturers in the automotive, farm implement, oil drilling equipment and general industrial fields.

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Magnetic Starters

Your most complete selection in the 1-50 hp range

NEW "IN-BETWEEN" SIZES SAVE ON COSTS AND UP TO 40% IN SPACE

Why Pay for Starter Capacity You Never Use? Now you can select the exact starter size matched to any application in the 1-50 hp range from the nine Furnas Electric sizes. Many in-between sizes can save you money and conserve space. Immediate delivery from stock.

Same Service, Less Money—Here's an example of how you can save: Suppose you want a starter for 10 hp service. It's no longer necessary to select a size 2 rated 25 hp. You save in cost and up to 40% in space by selecting a Furnas Electric type YE, the right starter for the job.

Important Features—1. Dual voltage coils matched to your motor. 2. Four-speed thermal overload protection. 3. Easy installation and wiring in shallow case. 4. Heavy contacts for long life.

Complete Range of Other Products—Pressure switches for air and water applications. Drum controllers for reversing, multi-speed and reversing multi-speed service.

Write today for Bulletin No. 5402, giving the full story. Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

FURNAS ELECTRIC
Batavia, Illinois

new post from Servel Inc., where he has served as assistant vice president in charge of air conditioning since 1951.

Lukens Steel Co., Coatesville, Pa., has named **Edward J. Charlton** manager of fabrication at the Lukenweld Div. and **William H. Funk** acting manager of the new products development department.

P. S. Tseu has joined Pastushin Aviation Corp., Los Angeles, as preliminary design aerodynamicist.

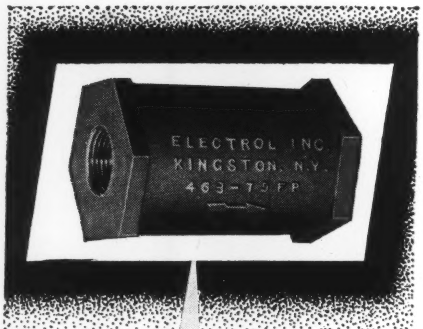
To serve as technical consultant on all products manufactured by the division, **Henry Magnuski** has been named associate director of research in the Communications and Electronics Div. of Motorola Inc., Chicago.

George Cory has been appointed senior design engineer by Associated Metal Fabricators, a division of Jersey Sheet Metal Products Inc., Clifton, N. J. He will be responsible for custom design of metal pallets and assembly line equipment to individual production requirements and for design of special industrial process equipment such as tanks and ovens.

Dr. G. B. Schubauer, formerly chief of the Aerodynamics Section of the National Bureau of Standards, has been appointed chief of the new Fluid Mechanics Section which will cover work formerly done in the Aerodynamics and Hydraulics sections.

Illinois Institute of Technology announced recently that **Herman H. Chanowitz** has joined the electrical engineering department staff as electrical engineer and that **Francis B. Porzel** has been named senior research engineer in the propulsion and structural research department.

Glenn J. Gibson has joined the engineering staff of Cooper Alloy Foundry Co., Hillside, N. J., to direct a research program aimed at developing improved methods



Electrol Check Valves

Prevent Reversal of Flow in { AIR . . . OIL OR WATER APPLICATIONS

Electrol (463FP) Check Valves are ideally suited for heavy-duty service applications—providing positive sealing against return flow in air . . . oil . . . or water control lines, with a minimum of pressure drop. They have a maximum operating pressure of 5,000 P. S. I., with a cracking pressure — in free flow direction —from 2 to 8 P. S. I. Elements are of brass and bronze — and include an O-ring check seat. Sizes range from 1/8" to 2" N.P.T. Your inquiries will receive prompt attention.

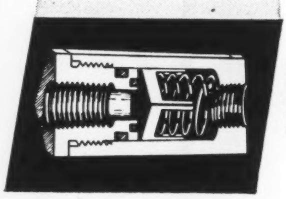


Diagram showing internal construction of the Electrol (463FP) Check Valve.

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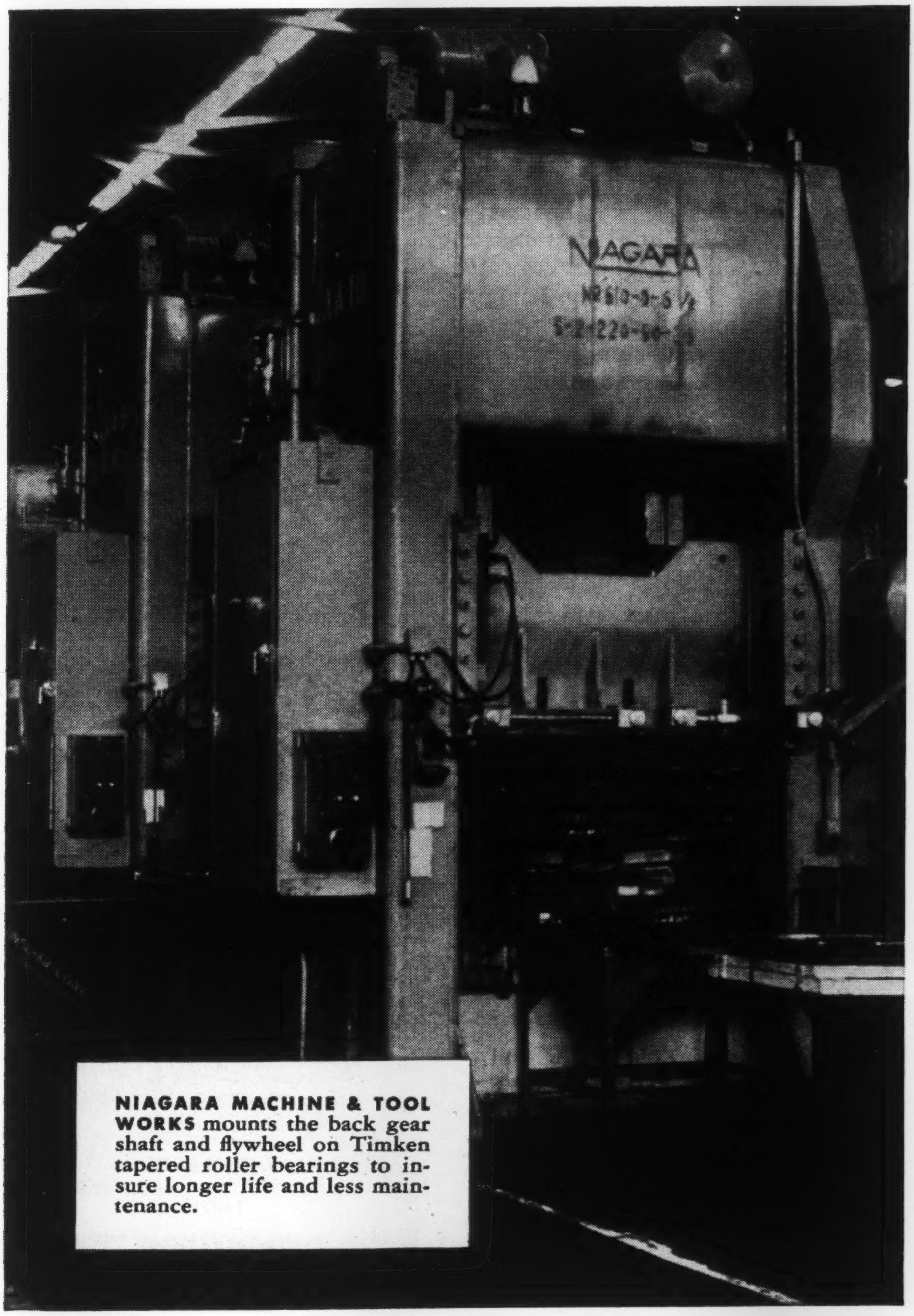
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

How TIMKEN® bearings cut maintenance on auto body stamping presses



NIAGARA MACHINE & TOOL WORKS mounts the back gear shaft and flywheel on Timken tapered roller bearings to insure longer life and less maintenance.

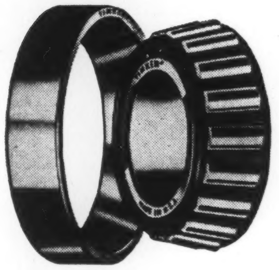
MAINTENANCE and downtime are low in the stamping department of one large automotive manufacturer. One reason: 30 new-design Niagara double crank presses have the back gear shaft and flywheel on Timken® tapered roller bearings.

Every time the press stamps a part, the bearings on the back gear shaft take the heavy shock load. Timken bearings take these loads with ease because rollers and races are case-hardened. This gives them a hard, wear-resistant surface over a tough, shock-resistant core. Full line contact between rollers and races of Timken bearings gives them extra load carrying capacity to hold shafts in line. There's minimum maintenance, less downtime.

Timken bearings help gears last longer, too. They insure accurate gear mesh because Timken bearings' tapered construction lets them take both radial and thrust loads in any combination. The taper prevents lateral movement of the shaft. Flywheels do not become worn or loose, crankshaft wear is prevented.

Be sure to specify Timken bearings for all the machinery you build or buy. They give longer life with less friction. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, O. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



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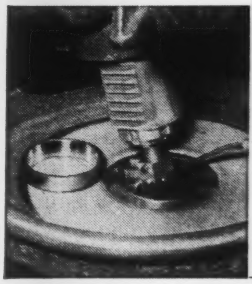
TAPERED ROLLER BEARINGS



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Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at the Timken Company.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

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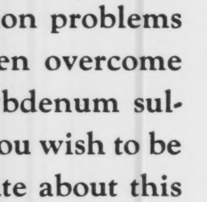

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for the welding of corrosion and heat resistant alloys. Mr. Gibson served for a total of eight years as a welding engineer with Pittsburgh-Des Moines Steel Co., and American Bridge Co., and for nine years as a research engineer with Air Reduction Co.

Prof. Loyal V. Bewley, head of the department of electrical engineering at Lehigh University, was named dean of the college of engineering. He joined the Lehigh staff in 1940, and before that time served as research engineer at General Electric Co. for 17 years.

Robert Armstrong has joined the quality control division of Ford Instrument Co., division of the Sperry Corp., Long Island City, N. Y. He was formerly associated with Electrol Inc. as quality manager and with Arma Corp., Pioneer Instruments Co. and the Aluminum Co. of America.

Formerly chief engineer, **Thomas H. Jeffers** was recently appointed assistant general manager of the Anaheim, Calif., division of Robertshaw-Fulton Controls Co. and at the same time was elected an assistant vice president.

William Dowd, an authority on centrifugal pump design, manufacture and application, is now associated with the Carver Pump Co., Muscatine, Ia., as consultant. He formerly designed large centrifugal pumps for R. D. Wood and Co., served Le Courtenay Co. as chief engineer, and was chief engineer and vice president of the Dayton-Dowd Co.

Hershel V. Hiatt has been named director of engineering for the Milwaukee division of Le Roi Co., a subsidiary of Westinghouse Air Brake Co. He will be responsible for the organization and direction of the engineering department, as well as for recruitment and educational policies and will also serve as chairman of the product development committees. Mr. Hiatt was formerly assistant chief engineer of the Allison Div. of General Motors.

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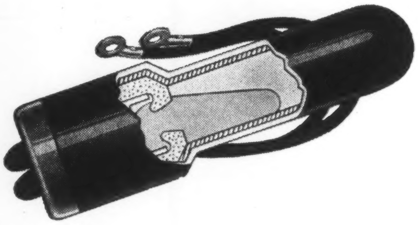

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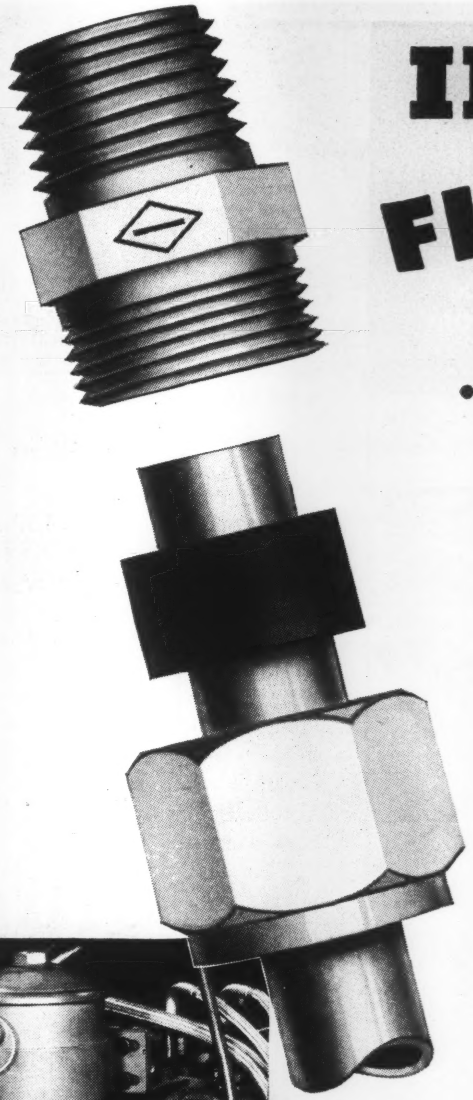

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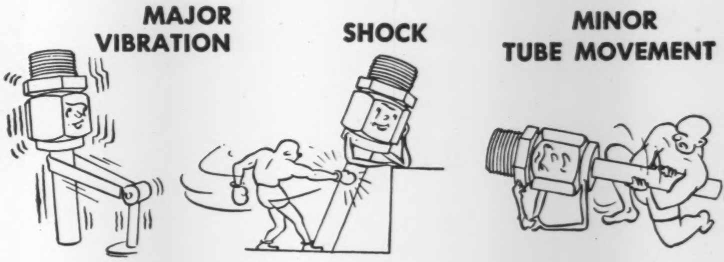
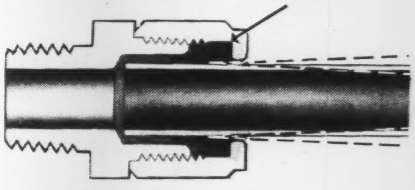
...Make Tube Fitting Failures Unnecessary...

They make up into safer joints that stand up under the most severe operating conditions of . . .



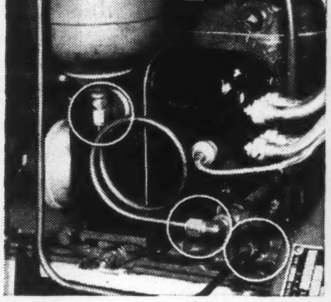
Flex Fittings Make Joints Virtually Indestructible by Vibration . . . On tests where ordinary fittings failed after 73,000 cycles of vibration, Imperial Flex Fittings have withstood over 20,000,000 cycles without failure as indicated in the chart at left.

This Elastic Sleeve in Flex Fittings Absorbs Vibration and Shock . . . permits tubing to flex back and forth through the angle shown . . . at the same time assures a positive, pressure-tight seal.



Easy to Install . . . All that is necessary is to slip nut and Flex sleeve over tubing. Then insert tubing into body as far as it will go and tighten nut to shoulder on body. No guesswork on how far nut should be screwed down. On sizes larger than ½" O.D. and where higher pressures are involved, end of tubing should be belled slightly.

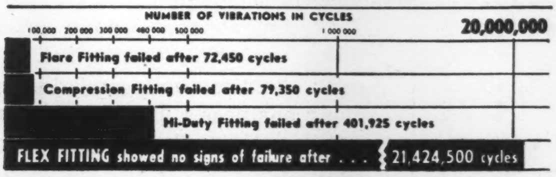
Flex Fittings Can Be Used with All Kinds of Tubing . . . Proved by Extensive Use.



If you are having trouble with tube fittings due to the destructive elements mentioned above, why not use Imperial Flex Fittings as does the manufacturer of the engine in this engine-generator set. Flex Fittings are used as standard equipment on trucks, tractors, diesel engines, oil filter connections, heavy power equipment, machinery, etc.

Ask for Catalog No. 344-C.

Comparative Vibration Test



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Pioneers in Tube Fittings and Tube Working Tools

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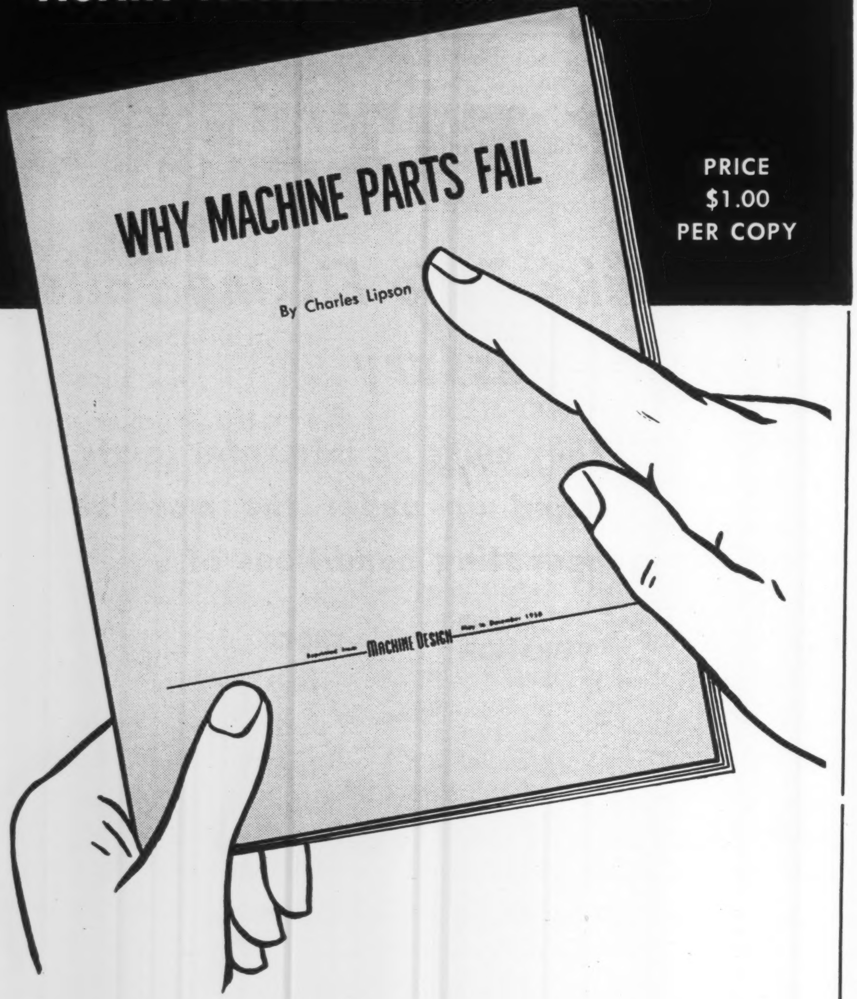
WHY MACHINE PARTS FAIL
By Charles Lipson
Reprinted from MACHINE DESIGN May to December 1950

It's not new but it's still useful.

This is an obvious deduction from almost four years of continued requests for copies of "Why Machine Parts Fail".

Charles Lipson's tremendously popular series first appeared in the May 1950 issue of MACHINE DESIGN and was concluded in the December issue of the same year.

It was reprinted in 1951 to meet the demand for copies. But that supply ran out nearly a year ago.

Not so the requests. They have continued in such volume that we have decided to reprint the series again.

You can get copies by simply filling out the form below and sending it in to us. We shall appreciate your enclosing remittance to facilitate handling.

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Send me . . . copies of "WHY MACHINE PARTS FAIL"
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Price $1.00. Orders in Ohio subject to 3% sales tax.

Stress Relief

MANY'S the man who envies the boss. Here J. P. Henderson imparts some realism to the dreams and aspirations of those who wish to be bosses.

Those Decisions

The designer walked into the boss's office and found him sitting back in his chair, gazing out the window, his feet up on a pulled out drawer.

Pretty soft, the designer thought. No rigorous hours for him. Even when he's here he takes time out to be lazy. No desk piled high with work. He dumps it all on us. I wonder what he's grinning about. Probably the president gave him a raise.

The designer cleared his throat . . .

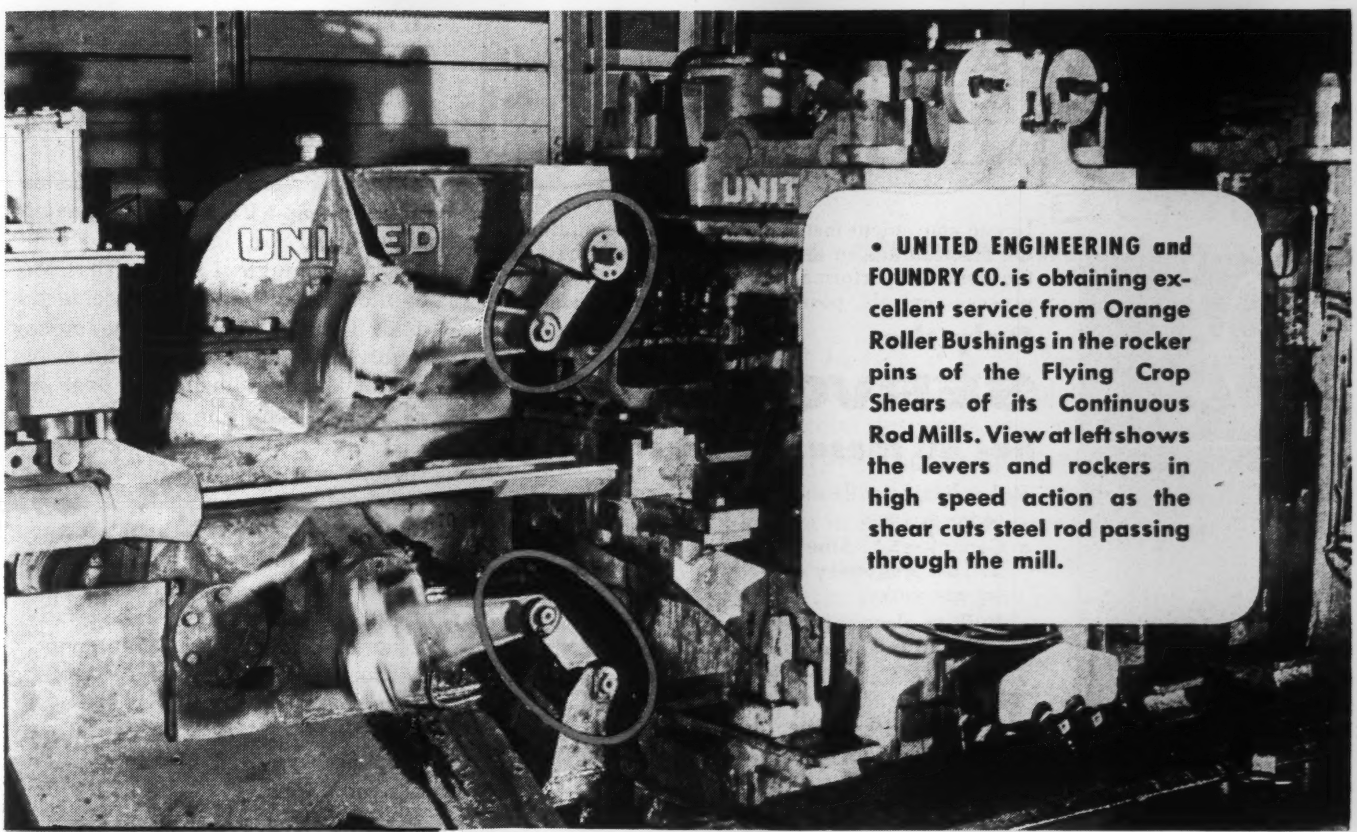
Let's hold this scene like that for just a moment.

Once upon a time three directors of the company invited me to take a trip with them. We were to visit a factory which had a fairly successful record but which needed new financing. The directors had the complete financial data on the concern and also had the opportunity of handling some of the financing. The proposed plan could have taken the form of practical control, with a chance to co-ordinate this business with ours.

I was not taken along merely for the ride. The question was—how good was their product, how well would it supplement our line? Were their designs, their tooling and their manufacturing methods so strikingly unusual that we could benefit decidedly from the deal?

We spent three days at their plant, meeting personnel, going over their methods and discussing their business. The third night we got together, the directors and I, that is.

"Now J. P.," they said, "you needn't worry about whether this can be a bargain or not. We have all the financial dope. What we want from you is an engineering

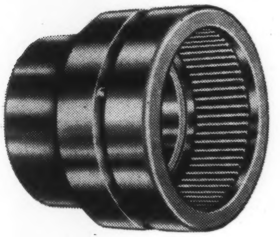


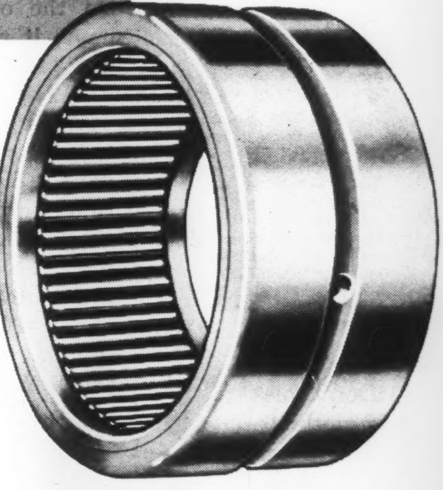
• **UNITED ENGINEERING and FOUNDRY CO.** is obtaining excellent service from Orange Roller Bushings in the rocker pins of the Flying Crop Shears of its Continuous Rod Mills. View at left shows the levers and rockers in high speed action as the shear cuts steel rod passing through the mill.

ORANGE ROLLER BUSHINGS

meet tough service requirements

Provide high capacity—require little space—stop friction and wear on shafts, parts, pins, etc.





Available in stock sizes from 1/2" to 8" shaft dia., fully interchangeable with all standard heavy-duty needle bearings. Stocked and serviced in all principal industrial areas.

Give your equipment longer life—less trouble—smoother, quieter operation by installing Orange Roller Bushings at all critical wear spots. These heavy-duty, precision needle bearings are performing with great success in all types of installations, under every operating condition . . . heavy loads, repetitive shock, 24-hour running, stop-and-go running, severe stresses, precision running.

Exacting control of roller uniformity by electronic gauging permits closer roller clearances, minimizes possibility of misaligned rollers while running. Wherever your designs call for needle bearings—specify Orange Roller Bushings to get the greatest combination of economy, capacity, compactness and trouble-free operation for your installation.

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ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.

opinion on their product, whether it is being manufactured economically and so on."

Anyone want an experienced designer cheap? Right then you could have hired me.

Even though I knew that my opinion alone might not decide the deal, I also knew that the money involved was in the millions and that I was playing away over my head in attempting a decision.

If I gave it my blessing, the directors and possibly our own company could lose hundreds of thousands of dollars. If I turned it down and other interests bought in and made a huge success of it, these directors would never see a dividend statement from that concern without drooling and looking askance at me.

In case you've worked up any suspense over this story—let me hasten to relieve it. I said "No." Other New York interests bought in, and a year later their financial statement indicated a loss of over $200,000 for their annual operations. Mutual congratulations were in order among our group.

Every engineering executive may not be faced with that type of decision. But what about the day-to-day cases?

Look at that patent of Carl's. Shall we go ahead with it? It may cost only a few hundred dollars but will it ever bring us in a cent? On the other hand if it's all we hope, it could add to our product and prove a moneymaker.

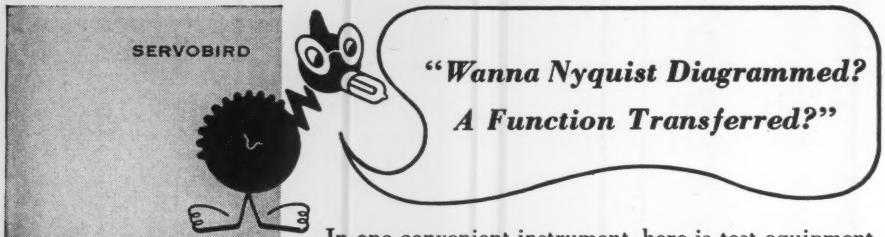
Yes or no?

What about the device that Sales is urging you to complete and market? You are not quite satisfied that it's ready to sell. Further investigations should be in order or the whole idea abandoned. They are persistent, and if you agree, about $80,000 in tooling is required. Once marketed it may do your company's reputation considerable harm.

Yes or no?

Those decisions add up over a year's time and, no matter how experienced and hardened the executive, they can cause worry.

Some years ago the thought was prevalent in some circles that executives were not worth their fancy salaries. No man could possibly be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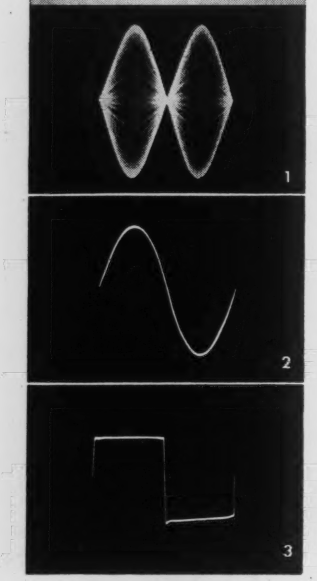
For detailed specifications write Dept. MD-5



Output wave forms of Servoscope displayed against internal linear sweep generator, frequency ½ cycle.

SC 110 C

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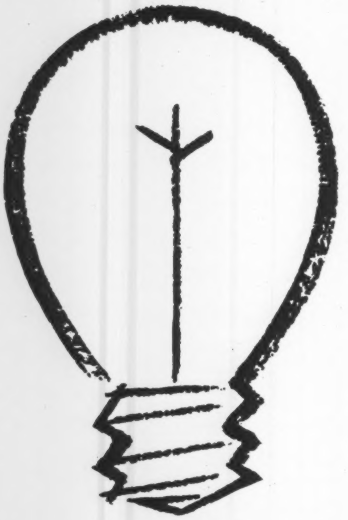

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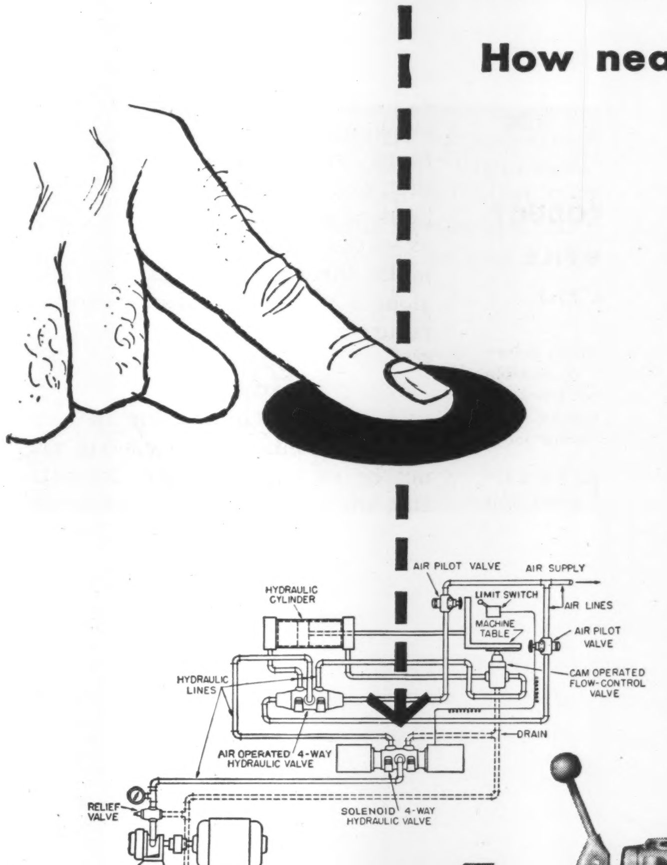
Push button production

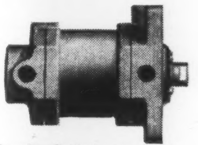
How near to its attainment are we?



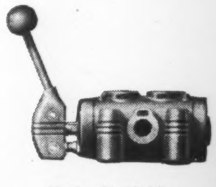
Very near! In fact, it is on the doorstep of every manufacturer, awaiting his planning the application of lately designed sources of power to his production processes. Some companies already have their plants on a nearly automatic basis, and the resultant cut in costs quickly pays for their investment.

Rivett is playing a part in this manufacturing advancement. Its air and hydraulic valves and cylinders are ideal power replacements for untold manual operations. And, more important, they are being used to power entirely original processes—offering tremendous short cuts in machining, forming, handling, finishing, etc.

Remember, productivity is your sole source of success. Attain it! And the one best way is to follow the example of many progressive companies and plan the use of Rivett air and hydraulic power!



Hydraulic Cylinders
108 models



Hydraulic Valves
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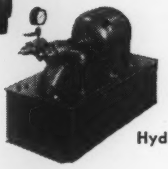

Hydraulic Power Units
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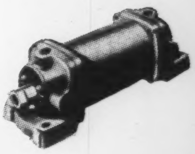
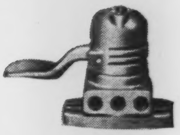


Air Cylinders
84 models



Air Valves
34 models

AUTHORITIES—in applying air and hydraulic power

Baltimore, Md.—Colliflower, Inc., Baltimore National Pike, Ellicott City, Md.
Boston, Mass.—L. W. Sheehy, 1104 Park Square Bldg.
Buffalo, N. Y.—Lane Engineering, 1807 Elmwood Ave.
Chicago, Ill.—MacMillin Engineering, 1737 Howard St.
Cincinnati, O.—Seifreat-Elstad Machy., P.O. Box 2508
Cleveland, O.—Garco Machy., 21000 St. Clair Ave.
Columbus, O.—Seifreat-Elstad Machy., P.O. Box 922
Dallas, Tex.—Womack Mach. Supply, 6409 Maple
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Minneapolis & St. Paul, Minn.—Anderson Machine Tool Co., 2641 University Ave., St. Paul.
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New York City—The Airoyal Company, 6 Church St.
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Dept. MD5 RIVETT LATHE & GRINDER, INC. • Brighton 35, Boston, Mass.

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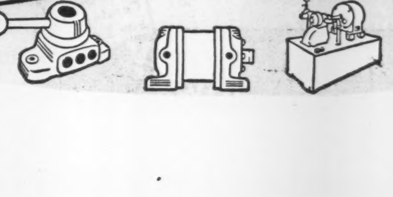
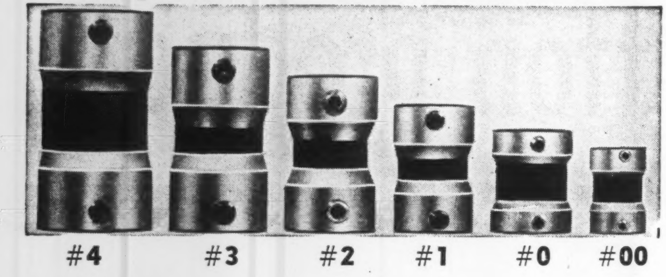


Needed: A "Wasp Waist" with "REACH"

specify Guardian FLEXIBLE COUPLINGS...



Freedom of the designer to select and specify the exact length the drive requires—plus very low overall diameter of coupling for the capacity it carries—these are reasons for more and more Original Equipment Manufacturers specifying Guardian Dyna-Line Couplings.
Guardian molded DuPont's nylon Splined Sleeve couplings, now available in No. 1, 2 and 3 Series (1/6, 1/3, 3/4 HP @ 1750 RPM), provide instant absorption of lateral motion and adjustable positioning. In "tight spots" of difficult final assembly, the nylon sleeve locates, centers and mounts quickly and easily onto its grooved mating hub.
Our Product Application Department will welcome the opportunity of serving you.

HERE...

FROM OUR PRODUCT APPLICATION FILE
Case History No. 23-3

PROBLEM: Compacted design of a motor driven hydraulic control system required a flexible coupling not over 1¼" O.D. at any point, to couple motor and pump shafts spaced 2¼" apart: Must carry ¾ HP 1750 RPM motor load.

SOLUTION: Guardian Dyna-Line No. 3-R 4.25" long with Standard Flex-Element serves this Original Equipment Manufacturer's requirements. This length specification carries no "premium price for non-standard length".

Write for Catalog Page C102 and Drive Data Form #53.

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COUPLING DIVISION
Dept. IC-M, 1215 E. Second St., Michigan City, Ind.

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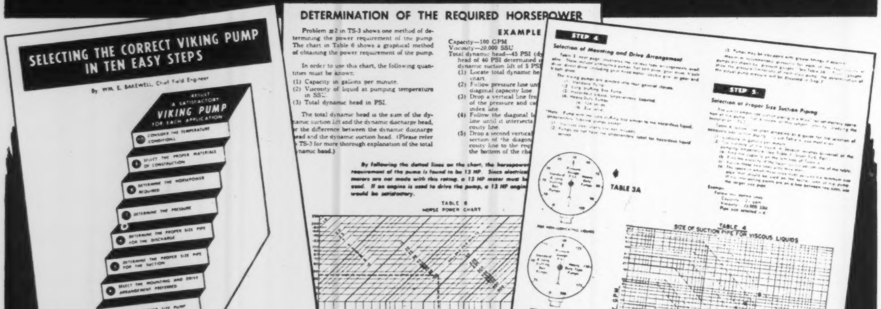
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Stress Relief

worth over, say, $25,000 a year nor produce even that much for his company. Tax it away, or better still disallow excess salaries or bonuses as legitimate expense in figuring corporation taxes.

Executives defended themselves on the basis of *decisions.* Top-level management is universally faced with important decisions that can cost their companies millions of dollars or even failure. An executive who does nothing but make three or four difficult decisions a year, all proved correct by future events, has made enough money for his company so that he has justly earned his high salary.

Farther down the line in executive personnel the decisions may not be as important nor dramatic. But the principle is the same and in the long run the executive knows that he must say "yes" or "no" correctly most of the time. Too many wrong answers in an entire executive group leads right to bankruptcy.

Now let's repeat that first scene with which we opened, going back a few moments:

The boss reached into the lower drawer on his desk and pulled out a large brown bottle and a spoon. Carefully he poured out a thick green slimy solution and with an expression of distaste he swallowed it.

Let's hope this quiets the ulcer, he thought. Maybe I can relax a little and think about that deal the president keeps after me about.

The designer walked into the office. Why is he looking at me so oddly, thought the boss. I wonder if he knows how lucky he is—makes good money, not too many worries.

Heck, here I am making faces again. My wife keeps telling me not to grimace like this when I have those gas pains.

The designer cleared his throat . . .

—J. P. HENDERSON

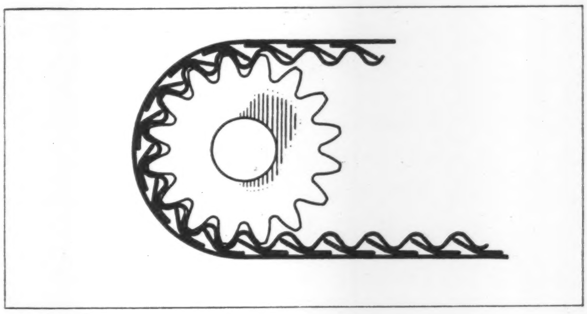
They Say . . .

"Idealism increases in direct proportion to one's distance from the problem." — JOHN GALSWORTHY, from *Miniaturesque.*

NOTEWORTHY

Patents

CORRUGATED METAL BELT for sprocket drives offers light weight construction with high load capacity. In a design described in patent 2,669,127 a sinuous sheet-metal ribbon is riveted to a flat sheet-metal tension strip to form an endless drive belt.



Power is transmitted through the ribbon corrugations which act as teeth and engage the sprocket wheels. High resistance to shear and tension loads is achieved through the use of stiffener plates which back up each belt "tooth" face. W. H. Raser Jr. is the inventor.

LEAK-TIGHT SEALING of static machine members of cylindrical shape subject to fluid or pneumatic pressures is provided by a one-piece seal design covered in patent 2,657,825 assigned to General Motors Corp. by A. F. Erickson. Sealing element is a flexible ring of rectangular cross-section which is mounted in an oversize mating groove with chamfered edges. Under pressure, the ring material is forced into the wedge-shaped space formed by the outer member and one of the chamfered edges. Effective sealing, regardless of the direction of pressure, is provided by the unit which can shift back and forth in the groove and is actuated automatically by pressure forces. Recommended groove and seal dimensions are detailed in the patent.

DEMAND POWER REQUIREMENTS are met with a fluid coupling design that can be used as a rigid shaft connection or as an adjustable fluid clutch. Shown in patent 2,654,223 issued to Eugene Wang, the coupling employs adjustable sliding axial vanes on the driven impeller to regulate the rate of power transfer through a fluid medium being circulated in a radial path by the mating driving impeller. Infinite adjustment of power output from full engagement to release is achieved through an externally

STRENGTH WITHOUT BULK

The exceptional tensile and torsional strength of Mac-it Screws makes it possible to use smaller, lower cost screws for all fastening jobs. Mac-it Special Alloy Steel used in all Mac-it Screws is held to rigid specifications, assuring uniform and dependable screw fasteners.

PRECISION FASTENERS

The precision manufacture and quality control used in making Mac-it Screws provide users with high dimensional accuracy and uniformity. All Mac-it Screws in both coarse and fine threads are held to a class-3 fit.

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Mac-it maintains a fastener engineering service for the design, development and production of screws to suit all types of applications.

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ONE MAC-IT CALL GETS 'EM ALL!

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Mac-it is geared for either large or small run production of screws with special design or strength characteristics.

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Mac-it heat-treatment is more than a mere case hardening or surface processing. The high quality of Mac-it Special Alloy Steel adapts it to heat-treatment that penetrates throughout the structure of the screw so that the center possesses the same sturdy toughness possessed by the outside. Proved formulas govern this process.

Each type Mac-it Screw is heat-treated to possess maximum strength for the particular purpose for which it is to be used. No one heat-treatment is best for all purposes.

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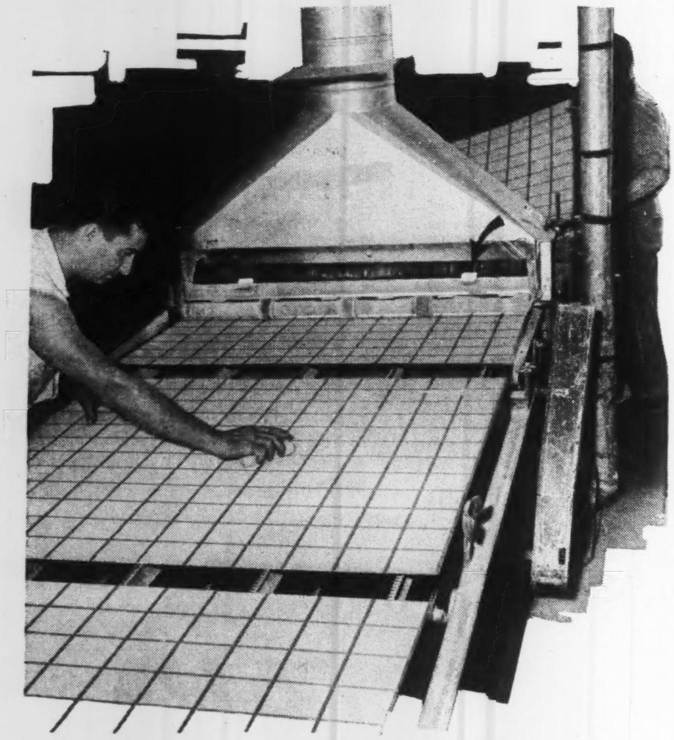

Operator sands down pips and rough spots before paneling passes between Pittsburgh brushes shown under exhaust hood.

Modern way to dust walls and ceilings

In producing wall and ceiling panels at the Barclay Manufacturing Co., New York City, dust caused by routing simulated "mortar lines" settles on the panels. The panels must be "dusted"—the dust *completely* removed—before they can be bake-finished.

Brushes originally used had a short life span, wore unevenly, and did so poor a job that many baked panels had to be completely refinished to pass inspection. Since even a "fairly good" brush would not do, Barclay searched for the *perfect* brush—and chose Pittsburgh! Result: Better work and costly refinishing eliminated!

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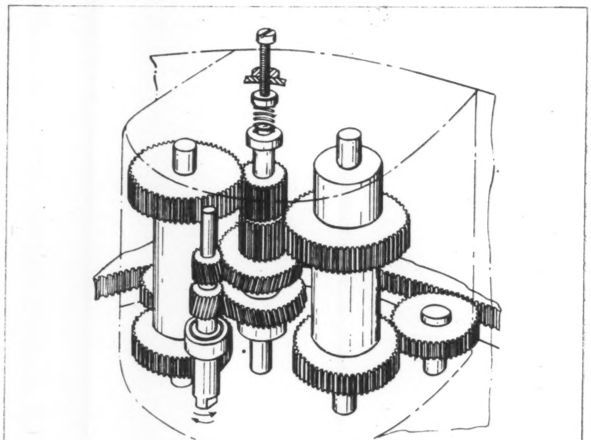
operated linkage which controls the projection of the sliding vanes into the moving fluid and simultaneously actuates a sleeve valve to vary the fluid-flow rate. In addition, the impeller hubs carry a jaw type clutch which is engaged through a second linkage to provide direct mechanical connection of the input and output shafts.

AUTOMATIC BACKLASH TAKEUP for reversible spur gear drives is obtained with a novel tensioning mechanism employing helical gears. Described in patent 2,655,050, the device is suitable for use with gear trains operating at high speeds and will not affect the inertia of the system during takeup. Power is transmitted to two spur drive gears through a double helical gear set mounted in a herringbone arrangement. Each of the spur gears is connected rigidly to a helical gear by means of a countershaft construction; one of the helical gears is spring-loaded axially and is free to slide in and out or rotate independently of the other. When slack exists between the engaged spur teeth, spring action imparts a relative axial movement to the meshed helical gears, producing opposite forces of rotation and driving the spur gears into firm engagement. The patent has been assigned to Minneapolis Honeywell Regulator Co. by inventors R. E. Divette, W. H. Gille and W. L. Huntington.



AUTOMATIC SPEED CONTROL for V-belt drives is obtained by means of expandable-groove sheaves in a constant-speed transmission described in patent 2,651,210. Designed by A. R. Clark, the transmission employs two tapered single-groove sheaves with movable sides and is controlled through a fly-ball governor unit which changes the drive ratio to maintain a constant speed at the driven sheave. Speed variations at the driving sheave actuate the governor which au-

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Design engineers have confidence when they specify dependable Eastern Hydraulic Pumps and Fluid Motors. Exclusive Eastern features create an economical, reliable, and compact unit for the heart of your hydraulic mechanism.

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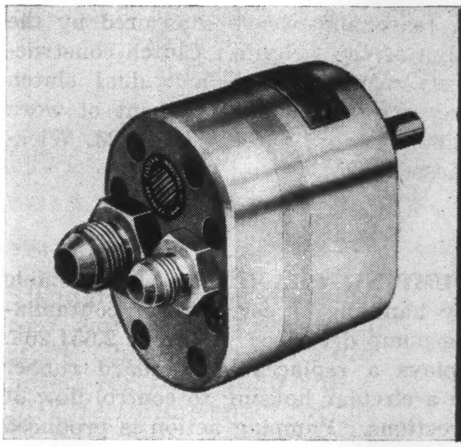
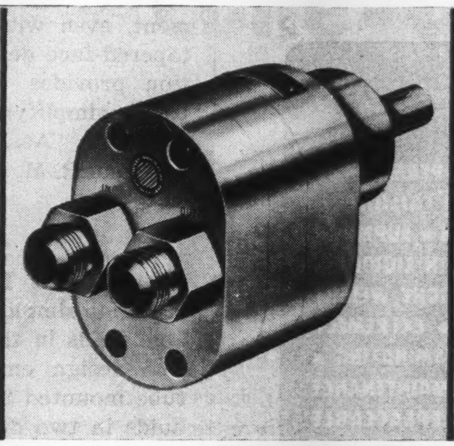
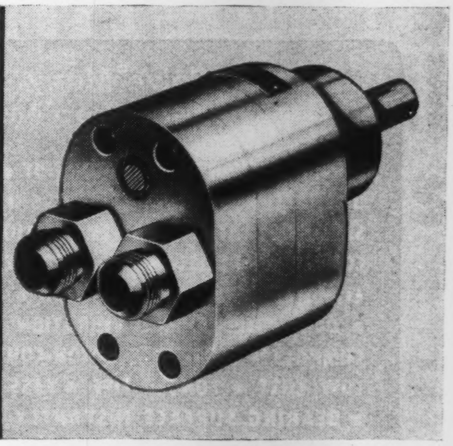


100 Series — Heavy duty gear pump. Delivery from .1 to 5 gpm and working pressures up to 1,500



700 Series — High pressure gear pump. Delivery from .6 to 9.6 gpm and pressures up to 1,500 psi.



2700 Series — Gear type fluid motor. Torque output — 0 to 15 ft. pounds.

Send for Eastern Hydraulic Catalog G-800. Contains valuable engineering diagrams and information.

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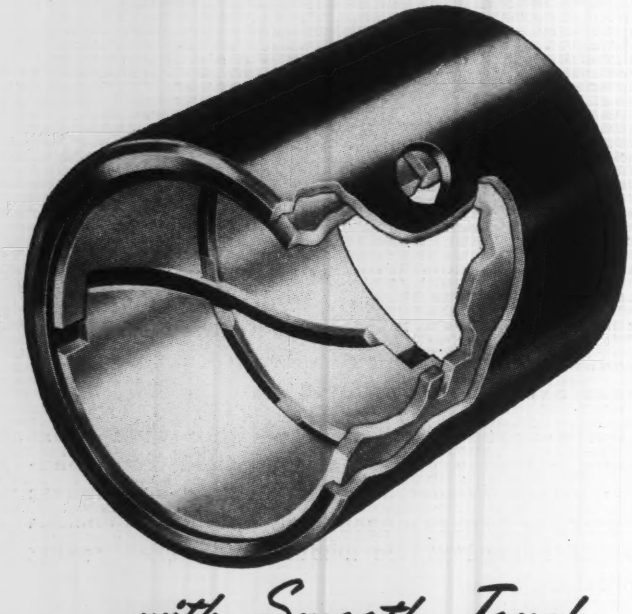
BEARINGS



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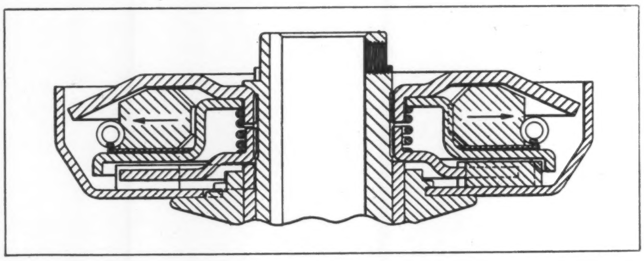
The Ball Bearing for Linear Motions

tomatically adjusts the axial position of the movable side on the driven sheave, changing the groove width and the effective pitch diameter. Simultaneously, the driving sheave, which has a spring-loaded movable side, is actuated by the change in belt tension to accommodate the new belt position. The patent has been assigned to International Harvester Co.

CENTRIFUGAL CLUTCH DESIGN minimizes effects of frictional wear and facilitates maintenance and adjustment. Assigned to Automatic Steel Products Inc., the clutch described in patent 2,650,685 employs weights with tapered faces, restrained by an encircling garter spring, to provide clutching action. At a prescribed speed, the weights move out under centrifugal force to engage a dished flange on the driven member. Speed of engagement is controlled by the restraining spring and may be readily varied by changing the spring strength. Uniform pressure of engagement, even with reasonable wear, is assured by the tapered-face design of the weights. Clutch construction provides easy access to the individual clutch parts, simplifying removal and replacement of worn members. Assignors of the patent are A. M. Wickwire and R. M. Kessel.



TUBULAR PUMPING CHAMBERS of a flexible material simplify handling of corrosive or contaminable fluids in the pump described in patent 2,651,264. The design employs a replaceable standard rubber tube mounted in a circular housing to control flow of fluids in two directions. Pumping action is produced by an eccentrically mounted rotor which successively compresses the tube as it rotates. Creeping of the tube is prevented by restricted inlet and outlet openings in the housing which act as clamps, crimping and retaining the tube as it passes through. Flow pulsations are eliminated by an overlapping tube assembly at the inlet and outlet openings. Pump construction permits assembly and removal of the tubes in their housing without requiring disconnection of the ends. The design is particularly suited for handling sterile fluids since the fluid passage is completely separated from the pump mechanism. Modification of tube size and rotor diameter permit variation of the pump capacity. Inventor P. M. W. Bruckmann has assigned the patent to the De Florez Co. Inc.

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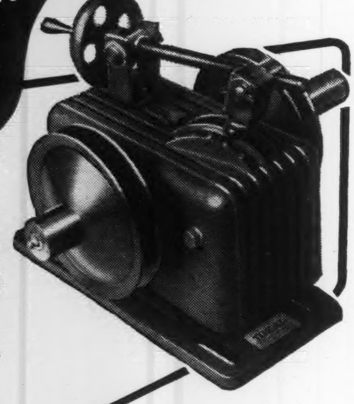

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New Machines

Domestic

Electric Ranges: Five models are included in line of ranges. Equipped with either three or four surface units with seven-heat switch control, 20-in. range has full-size oven with infra-red broiler. A 23-in. oven and four surface units with seven-heat control switches are combined in the 30-in. model. A 40-in. range has one convertible Duo-Cook surface unit and three Vari-speed monotube units, a warming compartment and a fully automatic oven. A second 40-in. model has twin ovens and six surface units, two with seven cooking temperatures and four with Vari-speed controls. *Thermador Electrical Mfg. Co. Inc., Los Angeles, Calif.*

Upright Freezers: Two models have capacities of 11 and 15 cu ft. Larger freezer has in-the-door ice cream conditioner which keeps 1½ gal of ice cream at serving temperature. Smaller model has a Tilt-Stor door shelf which tilts outward for easy access to packages placed one behind the other. Both have door shelves designed to permit stacking of standard size frozen food packages at a 45-deg slant. Two deep door shelves, frozen juice can dispensers in the door, two removable baskets mounted on nylon rollers in the cabinet and a trigger-action locking latch are provided. Both freezers have three refrigerated shelves in the cabinet. The 15-cu ft model has two adjustable sliding shelves, the 11-cu ft model has one. A refrigerated storage well is located at the base of the larger cabinet. This freezer holds 525 lb and measures 71 x 33⅞ x 30½ in. Smaller unit holds 385 lb and measures 64⅜ x 33⅞ x 29⅞ in. *Major Appliance Div., General Electric Co., Louisville, Ky.*

Refrigerators: Line of 11 models includes two refrigerator-freezer combinations with freezer compartment on the bottom. Glacier Blue porcelain enamel cabinet liners and door interiors are used on all models. All but one have butter keepers, and six also have a 2-lb capacity cheese keeper in the door. Other features include hermetically sealed compressors, full-width freezer chests with self-closing doors, roll-out shelves on nylon bearings, twin aluminum crispers, gold color ice trays, and automatic pushbutton defrosting. Models range from 7.3 to 14.1 cu ft capacity, with 45 to 150-lb freezer compartments. *Admiral Corp., Chicago, Ill.*

Heating and Ventilating

Oil Burner: Model "4" Hev-E-Oil burner is designed for heating a building containing over 1500 sq ft of radiation surface. A low-pressure, air-atomizing type unit, it burns No. 4 or 5 heavy oil without preheating. Instantly sensitive to heat demands, it provides

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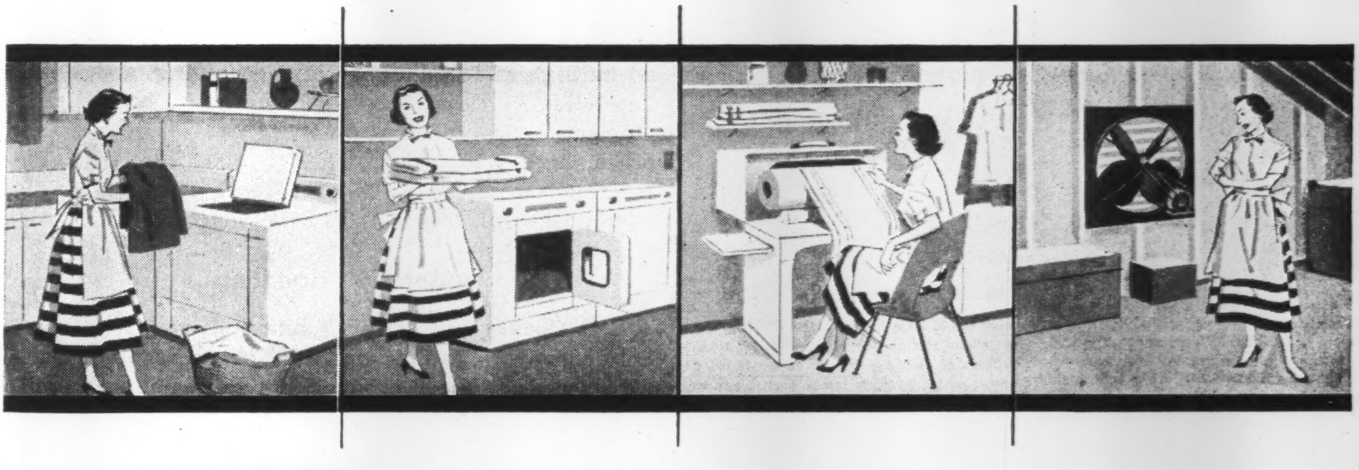

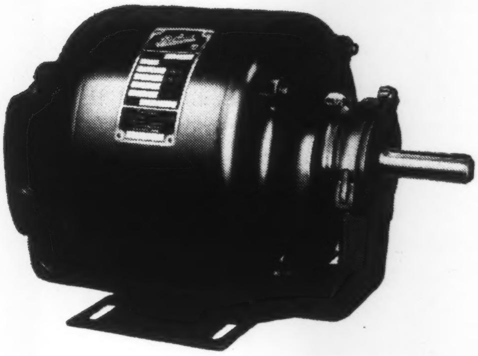

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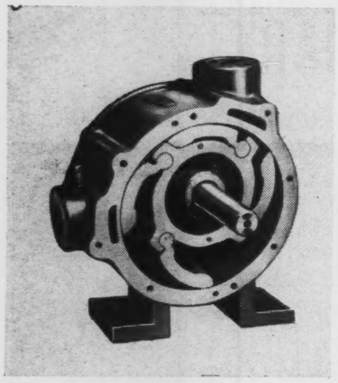
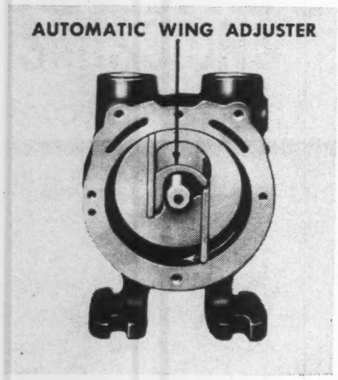


4-WING TYPE

Vacuums to 20"; pressures to 15 lbs.; displacement to 162 cfm. Wings hinged to piston—centrifugal force maintains close, continuous contact to cylinder wall. Wings take up their own wear, insure positive pressure or vacuum. No composition material to require frequent renewal. Air chamber is large because of small piston size, giving unmatched capacity for size and weight of pump.



2-WING TYPE

Vacuums to 29.9"; pressures to 25 lbs.; displacement to 40.8 cfm. Blades cannot stick, because of exclusive Leiman automatic wing adjusting lever which forces each blade to meet cylinder wall, insures positive pressure or vacuum. Only steel blades (no composition) are used. They take up their own wear, deliver years of trouble-free service.

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steady proportioned heat for power loads and heating. Burner is completely wired for installation. Control box is mounted on the burner. All primary and secondary air is furnished by the unit, and an oil metering pump measures correct amount for any given operating condition. Electronically controlled burner cannot be started on high fire and has a built-in low fire start. Carbon accumulation and clogging of burner nozzles is eliminated by self-cleaning action. *Cleaver-Brooks Co., Milwaukee, Wis.*

Cooling and Heating Units: Three types of packaged units available in various sizes. Flow-Cold chiller is available in six models ranging in capacity from 2 to 15 tons. Flow-Temp heat pump offers year-round temperature control system; heat source is water and power source is electricity. Six models deliver from 26,000 to 252,000 Btu per hour. Larger Flow-Therm packaged water chiller is made to specifications in capacities of 15 to 220 tons and is adaptable for heat-pump use on larger installations. *Acme Industries Inc., Jackson, Mich.*

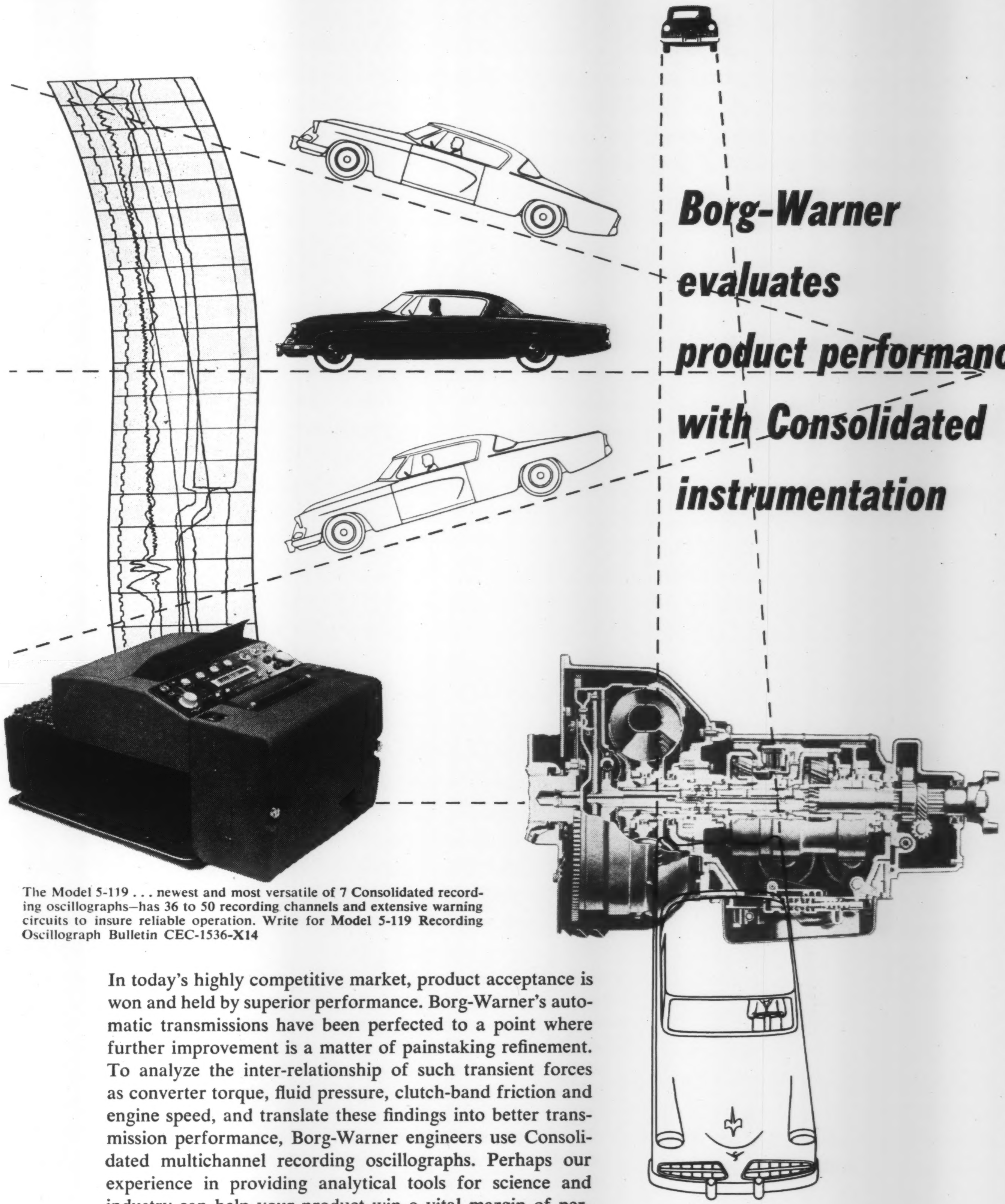
Air Conditioners: Compact air and water-cooled units include downflow and horizontal models designed for use in basementless houses. They are available in 1½, 2, 2½ and 3-ton capacities. Upflow models are available in these sizes as well as in a 5-ton model. Downflow cooling unit, in which air enters at the top, is filtered and cooled and exits at the bottom into ducts, is enclosed in steel housing 24 in. high and 36 in. deep in widths of 25 and 29 in., depending on capacity. Upflow units are improved in efficiency and quietness of operation. They measure 55 in. high, 30 in. deep, and 21 and 25 in. wide, depending on capacity. *Home Heating and Cooling Dept., General Electric Co., Bloomfield, N. J.*

Materials Handling

Belt Conveyors: Series of power driven, wire mesh belt conveyors can be operated at constant or variable speeds to meet production requirements. Available in capacities to handle light and heavy products, belts are used in operations such as washing, spraying, cooling, freezing, drying, annealing, molding and heat treating. *Sage Equipment Co., Buffalo, N. Y.*

Bulk-Handling Truck: Model 20 gasoline-powered Shoveloader has a 12-cu ft bucket and lifts 1500 lb of bulk materials to a height of 7 ft. It has 90-in. turning radius and is suitable for working from boxcars, bins and stockpiles. With one reverse and four forward speeds, truck has maximum travel speed of 14 mph. It can also be used with adjustable lift forks or special bucket and crane hook. *Baker-Lull Corp., Minneapolis, Minn.*

Lift Truck: Model RC-150 has capacity of 15,000 lb at 24-in. load centers. Mounted on 8.25 x 20 pneumatic tires, it is powered by a heavy-duty water-cooled industrial engine. Truck performs well in all types of weather and on rough terrain. Smaller in size than trucks with similar capacity, it has sufficient underclearance to allow safe travel over rough



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surfaces and inclines. Truck is also available in capacities of 16,000 and 18,000 lb at 24-in. load centers. *Hyster Co., Portland, Oreg.*

Vibrating Feeder: DPS vibrating bowl feeder provides automatic, oriented, single-line feeding to grinding, packaging, inspecting and many other automatic machines and operations. Handles finished ground parts and fragile pieces that normally could not withstand tumbling. *Detroit Power Screwdriver Co., Detroit, Mich.*

Skid Turner: Handles stock 52 x 76 in. in size and 5000 lb in weight. Turning a skid requires less than three minutes; operation is pushbutton controlled. Minimum pressure holds material in place, eliminating damage during turning. *Southworth Machine Co., Portland, Me.*

Metalworking

Turret Drill: Performs as many as six different drill-press operations, including tapping. Six-spindle turret has a combination locking-pin drive and mating-taper automatic alignment mounted on the single quill. Spindle speed, depth control and automatic reversal for tapping can be individually preset for each spindle. Only the spindle in use rotates, all the others pointing away from the operator. Turret can be indexed in either direction. Head and work table adjust to allow any clearance to 30 in. Throat clearance is 14½ in. Rated drill capacity is ½-in. in steel. Spindle speeds range from 200 to 4000 rpm. A depth stop holds preset depth to within 0.002-in. Setting up the spindles for six different speeds and depths can be accomplished in a few minutes. Machine requires 34 x 50 in. of floor space. *Howe & Fant Inc., East Norwalk, Conn.*

Precision Grinder: Model APW, designed for full wet grinding, has a separate motor-driven coolant pump, pan, settling tank, piping, valves, adjustable nozzles, and flexible neoprene spray guards. Front, side and top angles can be precision set in both vertical and horizontal planes. Feed is controlled by a micrometer feed knob with 0.001-in. graduations. Reciprocating-action holder permits manual rocking of work back and forth across entire face of grinding wheel. Machine has indexing table and either vitrified or diamond wheels for roughing and finishing. *Thomas Prosser & Son, New York, N. Y.*

Punch Press: Rated at 1½ tons for continuous heavy-duty work, small press has standard ¾-in. stroke; 1-in. stroke is available. Press is open-back type and is inclinable. Other characteristics include solid alloy steel crankshaft, roller bearing flywheel mounting, self-contained clutching mechanism independent of crankshaft, special alloy bronze connecting rod and crankshaft bearings, and 90-deg V-type ram and ram guides. *Kenco Mfg. Co., Los Angeles, Calif.*

Pneumatic-Hydraulic Drill: Model 04, measuring 4¾ x 6 x 23¼ in., is a pulley-drive spindle drill unit with a capacity of ¾-in. in mild steel. Spindle speeds

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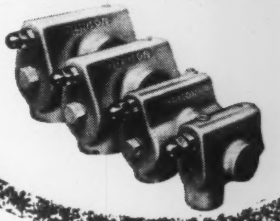

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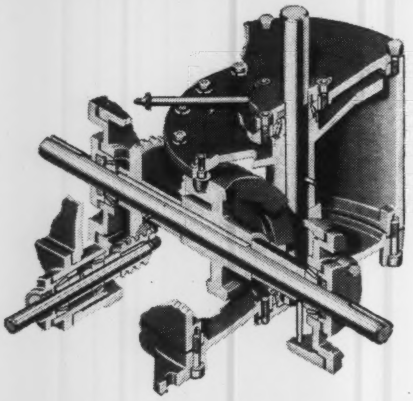

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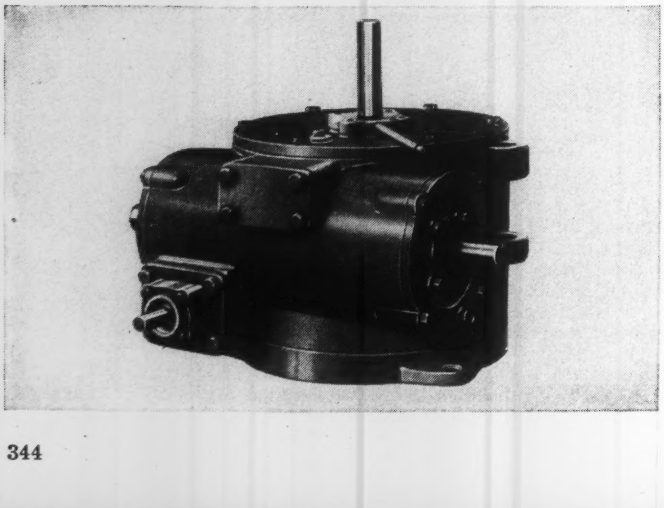

range to 5000 rpm. Stroke is adjustable to 4 in. and can be set up for either automatic or manual cycling. Positive stop with dwell or instantaneous retract operation, continuous cycling, skip drilling, back feeding and manual jogging are possible. Advance and retract thrusts are developed by air pressure; feed rates are established by adjustable hydraulic controls. A $2\frac{1}{4}$ x $\frac{3}{4}$-in. diameter, keyed pulley shaft mounts standard fixed or variable-speed V-belt pulley drives. Drill can be mounted at any angle. *Hause Engineering, Montpelier, O.*

Milling Machine: Designed for vertical and angular milling operations, machine has balanced rigidity, simplified method of belt changing, conveniently mounted switch and tool storage compartment in the base. Vertical boring, end milling and dovetailing can be done. Vertical table has $9\frac{1}{2}$ x 36-in. working surface. Quill travel is $5\frac{1}{2}$ in. Floor space required is 60 x 75 in.; weight of machine is 1600 lb. *U. S. Burke Machine Tool Div., Cincinnati Mfg. Corp., Cincinnati, O.*

Drilling-Tapping Machine: Model 2F has variable-speed drive which allows instant speed selection without loss of time for changing gears or belts. Spindle speeds range from 200 to 3600 rpm. Back-gear attachment provides an additional range of speeds from 50 to 900 rpm. Capacity of machine with back gears is $\frac{7}{8}$-in. in steel, $1\frac{1}{4}$ in. in cast iron. Models with 8 and 15-in. overhang and from one to eight spindles are available in pedestal type machine; 8 and 15-in. overhang round column type machines are also available. *Edlund Machinery Co., Cortland, N. Y.*

Processing

Vacuum Forming Machine: Model HV-30-60 Hydro-Vacumatic is a self-contained unit for high-speed vacuum forming of thermoplastic films and sheets. Built-in components include an air compressor, mold clamp frame assembly which is adjustable in all dimensions, and a hydraulic pump which provides smooth, quiet press action. Machine operation can be completely automatic, semi-automatic, or manual. A 30 x 60-in. platen permits the use of plastic sheets 27 x 57 in. Molding and embossing under vacuum pressure can be done with a wide variety of thermoplastic sheet materials up to $\frac{1}{4}$-in. thick. Table is 33 in. from the floor, and clamp travel allows for 18-in. maximum depth of draw. Overall size of machine is 74 in. high, 73 in. wide, 68 in. deep; weight is 3000 lb. *Pamco Industries Inc., Bayville, N. Y.*

Conveyor Furnace: Operations such as tempering, annealing and stress relieving can be performed at temperatures to 1650 F with electric heating elements. Three fans circulate heated air, providing uniform temperature in the heating chamber. Conveyor has trays to hold small parts. A variable-speed drive mechanism adjusts conveyor speed; parts can remain in the furnace chamber from 13 to 130 min. *Hevi Duty Electric Co., Milwaukee, Wis.*

Vacuum Metallizer: High-vacuum metallizing unit is used to apply gold, silver, copper and aluminum

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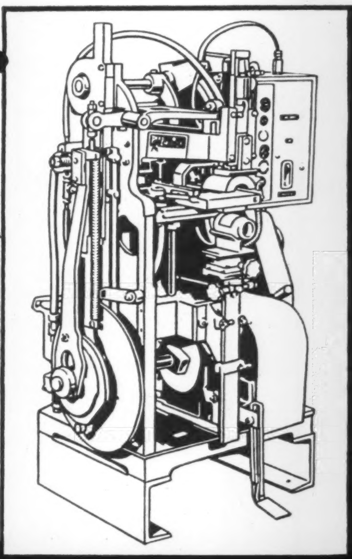

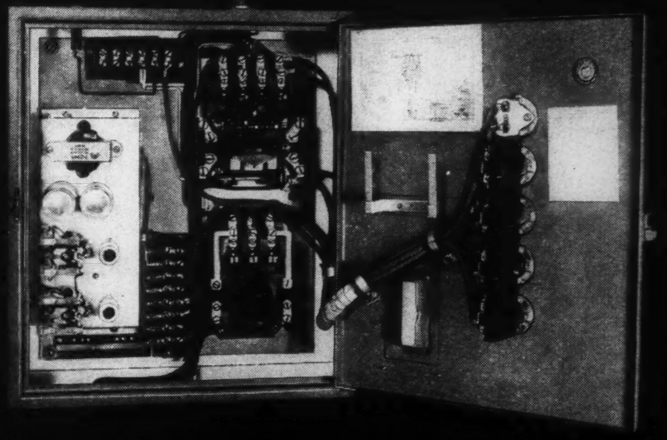

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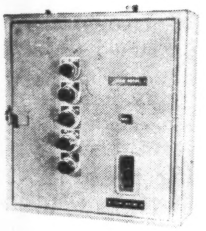

Federal Noark control unit for a New Jersey Machine Corporation's thermoplastic labelling machine that eliminated costly switch and relay chattering. At right above is opened unit showing electronic brain, Federal Noark manual and magnetic motor starters and oil-tight push-button switches.

AN IMPORTANT OPERATIONAL PHASE of the New Jersey Machine Corporation's well-known Label-DRI package labelling machines requires a heater plate to "fix" the labels. Correct temperature is maintained by small switches which formerly responded to even minor vibration and set up a loud chattering which shortened the life of the thermo switches and relays.

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